ECONADAPT

The Economics of Adaptation

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# Documentation of the climate scenarios and data developed and used in the case study WPs

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To find out more about the ECONADAPT project, please visit the web-site: www.econadapt.eu

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# Executive Summary

This document describes the process that was followed in WP1 to deliver appropriate climate information and data to the ECONADAPT case studies. Consistent with the adaptation-first approach of ECONADAPT, this work was undertaken once the case studies had been well established. As a first step, a survey of climate information needs was undertaken. A specific member of the climate team was then assigned to each case study to provide a single contact point for ongoing dialogue and interaction with the case-study team. While the survey provided a useful first picture of needs, the pairings of climate and case-study experts were ultimately more important and effective in establishing needs, and providing guidance and advice were necessary as to how the provided data and information should be used.

Each case study was found to be different in terms of spatial resolution (ranging from global averages to point locations) and temporal resolution (ranging from 30-year averages to daily time series), time periods (ranging from the next two decades to the end of the century), region and so on. Thus it was agreed at the project level that there was no need to ensure consistency in terms of the climate information and data provided for each case study. In terms of the climate projections provided to the case studies all are, however, based on Representative Concentration Pathways (RCPs), and outputs from CMIP5 Global Climate Models (WP7, WP8, WP9) and/or CORDEX Regional Climate Models (WP5, WP6, WP9).

The flexible approach adopted by WP1 was beneficial in reflecting the different needs and capacities of the different case studies. Some case studies have required little if any input from the climate experts (for example WP5 Pan-European disaster risk management and WP7 Policy impact assessment), while others have required more specific help in sourcing and processing/translating data (e.g., the WP6 Bilbao case study). In some cases, inputs have been sought from outside ECONADAPT (e.g., DIVA sea level projections for use in WP8 Macro-economic effects of adaptation). For WP9 International development support, the climate and case study experts are working together to identify and interpret the available climate information.

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# 1 Identification of case-study needs for climate information and data

One of the main objectives of ECONADAPT WP1 (Task 1e) is the development and integration of climate scenarios and climate data products in adaptation assessments, in particular in the case studies being undertaken in WPs 5-9. In keeping with the bottom-up, adaptation-first approach being taken in ECONADAPT, the climate scenarios and datasets were not put together at the start of the project and then 'handed down' to those undertaking the case studies as often tends to be done.

Instead, the case study adaptation teams were given an opportunity to develop their case studies, including contacts with relevant stakeholders, before the WP1 partners involved in providing climate scenarios and information for ECONADAPT (UEA and DMI) actively began work. Whilst UEA and DMI attended all early project meetings, this was primarily to listen and to begin to understand the approaches being taken by the different case studies. Then, as agreed during the second ECONADAPT meeting in May 2014, a survey of climate information needs was undertaken.

The survey questions are presented in the Appendix. The preliminary questions deliberately focus on the purpose for which climate information is required and the key questions it will be used to explore. Subsequent questions explore in more detail how climate information will be used in the case study, e.g., whether quantitatively or more qualitatively, to run impacts models and so on. The survey was circulated to all case studies in September 2014. Respondents were asked to answer as many questions as they felt able to and told not to worry if some answers were incomplete.

Responses were received shortly before the third ECONADAPT meeting (9/10 October 2014). This meeting provided an opportunity to present the synthesised findings and first proposals from the climate team as to how the identified needs could be met. A specific member of the climate team (Ole Christensen, DMI or Clare Goodess, UEA) was assigned to each case study as a single contact point. This person then took responsibility for ongoing interaction and dialogue with the case study team. The assigned climate expert got back in touch individually with each case study WP leader/relevant partner to discuss what data could be made available, in what form, and by when. In some cases this process was relatively straightforward, in others more discussion was needed to identify what could be provided in a usable form. Discussions took place via email, Skype and person-to-person during subsequent project meetings.

From project-wide discussions it was concluded that there was no need to ensure consistency in terms of the climate information and data provided to each case study. This is because each case study is different in terms of spatial and temporal resolution, time periods, region and so on. Furthermore, it is not expected that the results from the different case studies will be direcly compared using quantitative measures. In terms of climate projections provided to the case studies all are, however, based on Representative Concentration Pathways (RCPs), and outputs from CMIP5 Global Climate Models (GCMs - http://esgf.llnl.gov/) and/or CORDEX Regional Climate Models (RCMs - http://www.cordex.org/).

The outcomes of this process for each case study are summarised in Section 2.

# 2 Climate information and data provided to WPs

## WP5 Pan-European disaster risk management

**Ole Christensen (WP1) working with Reinhard Mechler (WP5)**

This case study primarily focuses on flood risk (and the associated fiscal risks), particularly up to 2030. It builds on flood risk modelling (e.g., using Lisflood) based on EURO-CORDEX and other climate model inputs, undertaken by JRC and other partners in a number of completed and ongoing EU projects including ClimateCost, Impact2C and HELIX (Jongman et al., 2014; Alfieri et al., 2015). The ECONADAPT climate experts are on hand to provide additional data and/or guidance (particularly if the case study is extended to encompass drought risk), but to date this has not been required.

## WP6 Bilbao case study

**Clare Goodess (WP1) working with Elisa Sainz de Murieta (WP6)**

This case study was originally primarily focused on the new urban area of Zorrotzaurre. In terms of climate information needs, it subsequently became more focused on adaptation to river flooding working with the Basque Water Agency (via Davia Ocio at URA). URA use their own statistical spatio-temporal model (based on the frequency of arrival and intensity of storm cells) to estimate rainfall over the catchment. The parameters of this model can be perturbed using projected changes in temperature and rainfall (at the start of ECONADAPT, URA had done this using mean monthly changes under the B2 and A2 SRES emission scenarios). Extreme runoff and peak flow are then estimated using these meteorological inputs in a hydrological model to explore flood risk (e.g., peak floods with 1, 10, 100 and 500 year return periods.

URA indicated that their capacity to handle multiple climate model runs was limited and that the timetable for their analysis was very tight. Thus initially UEA provided monthly mean data (mean rainfall and temperature, number of rain days) for the three requested locations (Bilbao, Donostia and Vitoria) extracted from the nearest ~12 km grid square from one EURO-CORDEX (Jacob et al., 2013) RCM run (HIRHAM forced by the ECEARTH GCM). This run was selected because it was considered to lie closest to the larger EURO-CORDEX ensemble mean in terms of changes in extremes of rainfall over Southwestern Europe (this analysis was undertaken by DMI and UEA for the MODEXTREME FP7 project - http://modextreme.org/). Data were provided in a simple table form (using the template provided by URA) for 1971-200 and 2071-2100 averages and for RCP4.5 and RCP8.5. URA were then able to use this first set of data to meet their prescribed deadline.

Following further dialogue (with Elisa Sainz de Murieta continuing to act as the intermediary between the climate expert and URA), focused in particular on the desirability of considering uncertainty in climate projections, an additional 10 EURO-CORDEX RCMs were processed by UEA. The full set of 11 runs sampled five GCMs and four RCMs. These data were also delivered in Excel table format.

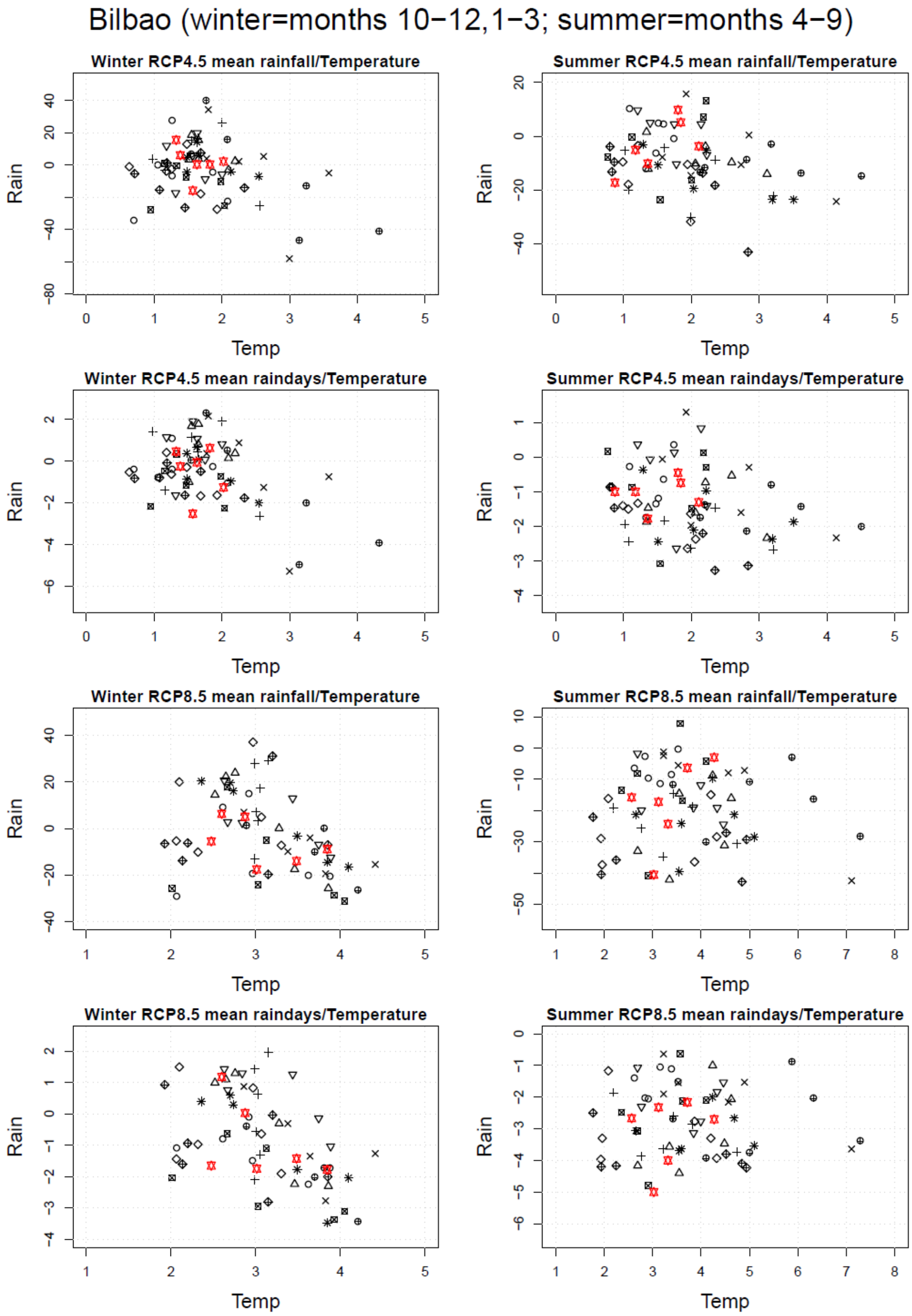


Figure 1: *Scatter plot of projected changes (2071-2100 minus 1971-200) in mean monthly temperature (horizonal axis) and rainfall (vertical axis) for Bilbao, for the six winter (left) and six summer (right) months, for RCP4.5 (top two rows) and RCP8.5 (bottom two rows). Data are from 11 EURO-CORDEX models – ECEARTH-HIRHAM is shown in red.*

In order to graphically illustrate the spread across these 11 models, UEA also provided some summary plots. The scatter plots (Figure 1) indicate that the ECEARTH-HIRHAM model originally provided is fairly representative of the ensemble – and could be considered to provide some sort of central estimate. However, the RCMs driven by one particular GCM (HadGEM2) give larger temperature changes, and other models have larger decreases in summer rainfall, and a stronger tendency to increases in winter rainfall. So it was recommended that URA should select two more runs – with the basis of selection depending on which variable/season they consider most important in terms of driving runoff extremes in the region. Feedback received during the ECONADAPT consortium meeting in November 2015 indicates that URA have produced flood risk maps based on the original single model run. Thus a short briefing note summarising issues relating to uncertainty in the projections will be provided to URA. The briefing note will also discuss changes in extreme rainfall events and the desirability of considering these, as well as changes in mean climate, in flood risk assessment.

# WP6 Czech Republic case study

**Ole Christensen (WP1) working with Jan Melichar (WP6)**

For the exploration of fluvial flooding around Prague, EURO-CORDEX (Jacob et al., 2013) data in high resolution for Europe was processed by DMI and passed to the Czech Hydrometeorological Institute (CHMI, Martin Hanel) for processing. The so-called EUR-11 data in roughly 12km resolution was delivered for an area roughly covering the Czech Republic. The fields provided were precipitation (pr) and surface air temperature (tas) in daily resolution for the period 1961-2100 and for RCP4.5 and RCP8.5. There were 14 simulation sets, each with its own combination of global model and downscaling regional model. Of these, one also contained an RCP2.6 transient simulation. Note that the historical period 1961-2005 is shared between scenarios (RCPs), i.e., the scenarios only differ from 2006 onwards for each model selection. Advice was also sought on what time periods should be used: the climate experts recommended 1971-2000 (present-day baseline), 2021-2050 (near-term scenario period) and 2071-2100 (far-term scenario period).

It is anticipated that CHMI will do their own bias correction of the RCM data using their own observational data. A relationship will be established between extreme rainfall (for the Vlatava basin) and extreme runoff (for Malá Chuchle upstream of Prague). Observed extremes will then be adjusted using the RCM information. Outputs from the CHMI model will be runoff and water level transferred to the flood extent of a given flood type. Thus the provided climate data will allow the case-study team to produce the return period estimates that are required for the adaptation assessment.

# WP7 Policy Impact Assessment

**Clare Goodess (WP1) in contact with Anne Biewald (WP7)**

The WP7 case study is being undertaken by IASA and PIK. In their completed survey questions, they indicated that they were self-contained in terms of climate data since they are already using the ISI-MIP fast-track outputs (Huber et al., 2014). These are bias-corrected datasets (Hempel et al., 2013) for five GCMs and four RCPs (RCP 2.6, 4.5, 6.0 and 8.5) on a standard 0.5 degree latitude/longitude grid (the so-called CRU grid). These are well-documented, publically-available datasets (https://www.pik-potsdam.de/research/climate-impacts-and-vulnerabilities/research/rd2-cross-cutting-activities/isi-mip/for-modellers/isi-mip-fast-track). Thus the climate experts agreed that these were very appropriate datasets to use for the purposes of WP7. The WP7 team knows that the WP1 experts are on hand if anything is missing, or any advice or guidance is needed – but this has not been necessary to date.

## WP8 Macro-economic effects of adaptation

**Clare Goodess (WP1) working with Ramiro Parrado (WP8)**

Based on the survey response and initial discussions, it was proposed that UEA would provide mean temperature from the five bias-corrected ISI-MIP fast track models (Hempel et al., 2013) aggregated to the country level for use in the CMCC CGE model. However, WP8 eventually requested annual mean global temperature (Tmean, Tmax and Tmin) rather than country averages. This was to capture changes over the oceans – the ISI-MIP bias corrected data cover land only.

Thus UEA selected five models from a larger set (ensemble) of 18 CMIP5 GCMs on the basis of mean global temperature change for RCP8.5 at 2041-2070 (Figure 2). Models were chosen which matched as closely as possible the five quantiles listed below:

| Quantile | Global temperature change (2041-2070 minus 1971-2000) for RCP8.5 |
|---|---|
| 5% | 1.9°C |
| 25% | 2.2°C |
| 50% | 2.4°C |
| 75% | 2.9°C |
| 95% | 3.0°C |

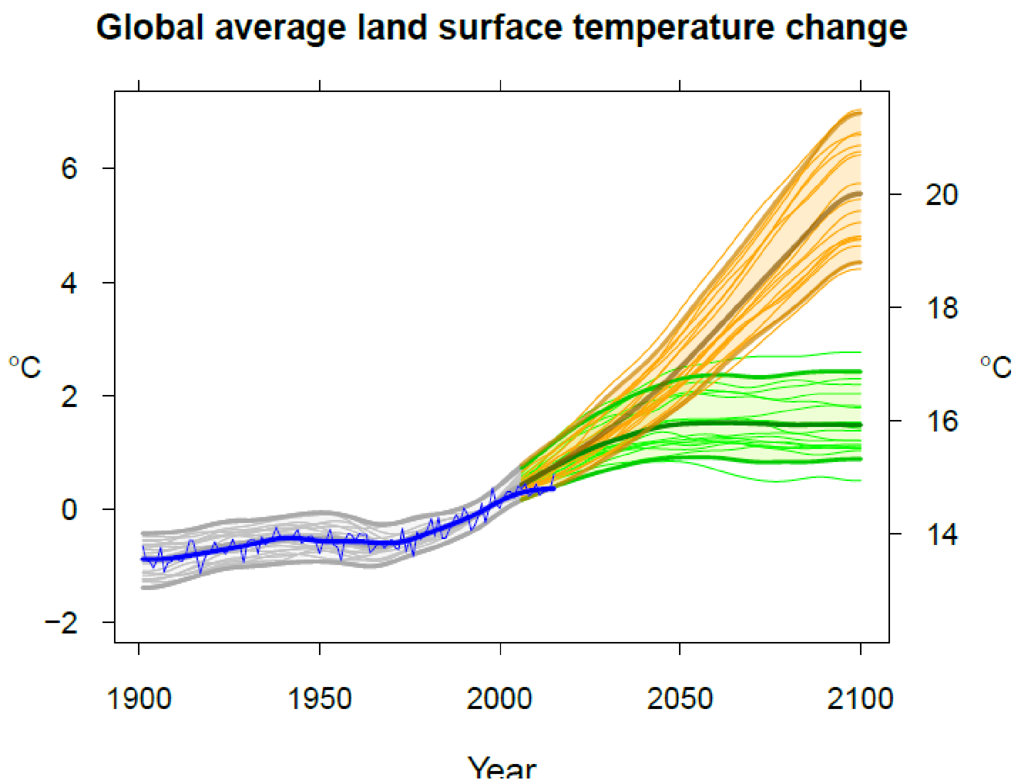


Figure 2: *Global mean temperature 1900-2100 from 18 CMIP5 GCMs for RCP2.6 (green) and RCP8.5 (orange). Thin lines: individual models; Thick lines: ensemble mean. Observations from CRU TS are shown in blue.*

Data were provided for RCP2.6 and RCP8.5 as this was already available in the Climatic Research Unit – but it was not possible to provide data for RCP4.5 since the international ESGF server where the CMIP5 data are archived was taken down unexpectedly in summer 2015 (due to security issues) and was still down at the end of 2015.

WP8 also required sea level projections at the country level. The DIVA model was identified as the best source of this information (Hinkel et al., 2014) and, through Paul Watkiss, contact was made with the DIVA group at the University of Southampton (Sally Brown). Following new procedures for the use of DIVA data, a Memorandum of Understanding for DIVA data to be used in the CMCC CGE model was drawn up and signed. During the latter part of 2015 there was ongoing discussion between relevant DIVA and ECONADAPT people to agree the way forward. DIVA has recently been substantially rewritten, thus a list was provided of variables (encompassing sea level itself and the impacts of sea level rise) that could be provided on a timescale (end of 2015) that would fit with ECONADAPT constraints. It was proposed to use a 'high' and 'low' scenario for each RCP (RCP2.6, 4.5 and 8.5) – noting that in the case of sea level a large part of the uncertainty is related to assumptions about the rate of ice shield melting [as well as to choice of GCM and emissions scenario – from the temperature data provided by UEA (see Figure 2) it will be possible to see where the DIVA scenarios fall in the larger range of CMIP5 global temperature change]. The work is being done as a collaborative, non-commercial activity between ECONADAPT and DIVA to ensure that the DIVA data are used appropriately and with due recognition. The possibility of a joint publication will be explored and it will acknowledge the collaboration between ECONADAPT, the ISI-MIP Project Fast Track funded by the German Federal Ministry of Education and Research (Project 01LS1201A), and the European Commission's Seventh Framework Programme's collaborative project RISES-AM-(contract FP7-ENV-2013-twostage-603396).

# WP9 International development support

**Ole Christensen (WP1) and Clare Goodess (WP1) working with Paul Watkiss (WP9)**

For areas around Rwanda and the islands of Zanzibar, respectively, CORDEX data from the AFR-44 area have been extracted by DMI. The area covers the entire continent in around 50km grid point distance. For Zanzibar, we have extracted precipitation, daily maximum and minimum surface air temperature (tasmax and tasmin) and sea surface temperature (sst) as daily values. For Rwanda there is no relevant sst, so only pr, tasmax, and tasmin have been extracted.

Africa has been a pilot area for the CORDEX initiative, and there are therefore many simulations to investigate and supporting literature (e.g., Nikulin et al., 2012, Endris et al., 2013, Kim et al., 2013). We have extracted 18 different sets of simulations, each with a unique combination of driving GCM and downscaling RCM and each with both an RCP4.5 and an RCP8.5 evolution after a common historical period. A total of 10 different driving GCM simulations, and a total of 4 different RCMs have been used. No RCP2.6 simulations were available at the time of data collection. UEA is assisting DMI in sourcing appropriate daily temperature and precipitation station data which could be used to bias adjust these outputs.

UEA has provided country averages for Rwanda and Tanzania based on CMIP5 GCM RCP2.6 and RCP8.5 simulations and CRU TS gridded observations. Plots have been provided for 10 indices of temperature and rainfall extremes, together with data files for Tmean, Warm spell duration index, Days > 20mm rainfall and consecutive dry days (observations, multi-model mean, 5$^{th}$ and 95$^{th}$ percentiles of the ensemble, and individual model values). This material was developed by UEA for inclusion in climate and health country profiles published by the WHO - http://www.who.int/globalchange/resources/countries/en/).

In addition to providing data, the climate experts are providing guidance and advice on issues such as how to present projected changes for Rwanda as equivalent changes in altitude of areas suitable for tea and coffee growing. A review of potential change in tropical cyclones is also being undertaken for the Zanzibar case study.

# 3 Concluding Remarks

While the survey of climate information needs provided a useful first picture of the climate information needs of the different ECONADAPT case studies, the pairings of climate and case-study experts were ultimately more important and effective in establishing needs through two-way dialogue and interaction.

The approach taken has necessarily been flexible – reflecting the different needs and capacities of the different case studies. Some case studies have required little if any input from the climate experts (for example, WP5 and WP7), while others have required more specific help in sourcing and processing/translating data (e.g., the WP6 Bilbao case study). In some cases inputs have been sought from outside ECONADAPT (e.g., DIVA sea level projections for use in WP8). For WP9, the climate and case study experts are working together to identify and interpret the available climate information.

The adaptation-led approach taken in ECONADAPT has some important wider messages for the development and implementation of climate services. Thus the WP1 Task 1e contribution to the ECONADAPT tool box will focus on this issue – based on self reflection by the climate expert team and feedback from the case-study 'user' teams.

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# Appendix: Survey questions

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|---|---|
| **WP number** | |
| **Short name to identify/describe the case study(ies)** | |
| **Lead partner for the case study** | |
| **Other partners involved** | |
| **Name of the person providing this information** | |
| **Email of the person providing this information** | |
| **Outline the general purpose for which climate information is needed** | |
| **What are the key questions with respect to past/present-day climate variability for this case study?** | |
| **What are the key questions with respect to future climate variability and change for this case study?** | |
| **Do you need quantitative or qualitative information?** | Quantitative (i.e., numerical data) / Qualitative (i.e., descriptive or story line) / Both / Don't know |
| **For what geographical region(s) or location(s) do you need information?** | *Please be as specific as possible* |
| **What climate variables are you interested in?** | *Please list all, e.g., temperature, rainfall, wind speed, snow depth, sea level* |
| **Are there particular weather/climate events, including extreme events, that you are interested in?** | YES /NO<br><br>If YES, please specify:<br><br>*e.g., heat waves, heavy rainfall, wind storms, storm surges* |
| **Please indicate at which spatial resolution you would like climate information** | *e.g., 50 km / 25 km / 12 km; point locations; regional averages. If relevant, please indicate the ideal spatial resolution and the minimal useful/acceptable resolution* |
| **Please indicate at which temporal resolution you would like climate information** | *i.e., annual, seasonal, monthly or daily; time series or long-term averages* |

| | |
|---|---|
| **Please indicate for which time periods (past/present/future) you would like climate information** | *e.g., last 30 years, last 100 years, next 20 years, next 30 years, next 50 years, next 100 years (give specific years if known, e.g., 2021-2050, 2071-2100…)* |
| **Will you use this information for input to models or software packages?** | YES / NO<br><br>If YES, please indicate which:<br><br>*e.g., specify any impacts models to be used, GIS packages……* |
| **Are there any particular formats in which you would like to receive climate data?** | *e.g., .csv, ascii, netCDF for numerical data; maps, figures, tables* |
| **Are there any particular formats in which you would NOT like to receive climate data?** | *e.g., .csv, ascii, netCDF for numerical data; maps, figures, tables* |
| **What approach(es) to uncertainty in climate projections are you considering taking?** | *e.g., want to consider plausible ranges; would like to know about 'worst case' scenarios; would prefer to focus on the 'most likely' scenario(s); will take a probabilistic approach* |
| **Do you have the climate impacts information needed for your case study?** | If YES: please outline the source of this information; do you know what climate inputs it is based on?<br><br>If NO: please outline what information, including any climate-related variables (such as river flow) you need |
| **What non-climate scenario information do you have or need?** | *If possible, please also indicate which emission scenarios, RCPs (Representative Concentration Pathways), SSPs (Shared Socioeconomic Pathways) you have/plan to work with* |
| **Do you already have any climate datasets (observed or simulated) that you plan to use in the case study?** | YES / NO<br><br>If YES, please briefly specify |
| **Is there anything else in terms of climate information / data / guidance / expert judgement that you need for the case study that is currently missing or not covered by the previous questions?** | YES / NO<br><br>If YES, please briefly specify |
| **Any additional comments?** | |