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ESPON CLIMATE - Climate Change and Territorial Effects on Regions and Local Economies

Applied Research Project 2013/1/4

Revised Interim Report

- Annexes -

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Further Details on the Methods and Results of the Exposure Analysis

1. Uncertainty in climate models

Several research projects have been carried out focussing on both, projected climate change itself but also on evaluation of accuracy and uncertainty of future climate projections. For this purpose, usually model runs for past decades are being compared with actual records of climate parameters but also different model outputs are frequently being compared with each other (see figure 1).

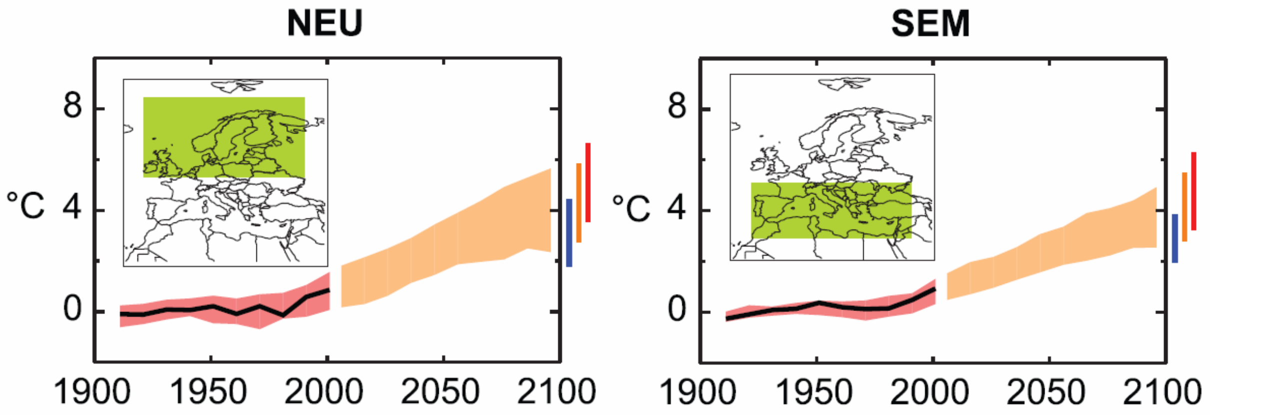

Figure 1: Temperature anomalies with respect to 1901 to 1950 for two Europe land regions for 1906 to 2005 (black line) and as simulated (red envelope) by MMD models incorporating known forcings; and as projected for 2001 to 2100 by MMD models for the A1B scenario (orange envelope). The bars at the end of the orange envelope represent the range of projected changes for 2091 to 2100 for the B1 scenario (blue), the A1B scenario (orange) and the A2 scenario (red). (Source: IPCC 2007 (1), p. 874)

One prominent project for the European region is the project *Prediction of regional scenarios and uncertainties for defining European climate change risks and effects* (PRUDENCE) which has been conducted within the 5th framework programme of the European Union[1]. Within this project different parameters of future climate change have been computed by 10 different regional climate models driven by the baseline global model HadAM3H as well as Arpege, CCM3 and ECHAM for comparison, prediction and assessment of uncertainties. The IPCC scenario A2 was mostly used for these experiments some made also use of the B2 scenario. The various outputs of the models employed haven been analysed and compared with each other (see figure 2) but are too extensive to be elaborated in more detail at this point. Generally, variations can be observed in model estimates concerning temperature as well as precipitation parameters (cp. IPPC 2007, p. 600) which are related to model internals and resolutions as well as driving models like in the case of most European regional models.

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[1] Another European research project, the ENEMBLES project funded within the 6th framework programme is oriented in a similar direction, aiming to "develop an ensemble prediction system for climate change based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe, validated against quality controlled, high resolution gridded datasets for Europe, to produce for the first time, an objective probabilistic estimate of uncertainty in future climate at the seasonal to decadal and longer timescales" (website ENSEMBLES). The project is currently still running and is due to be finished end of 2009.

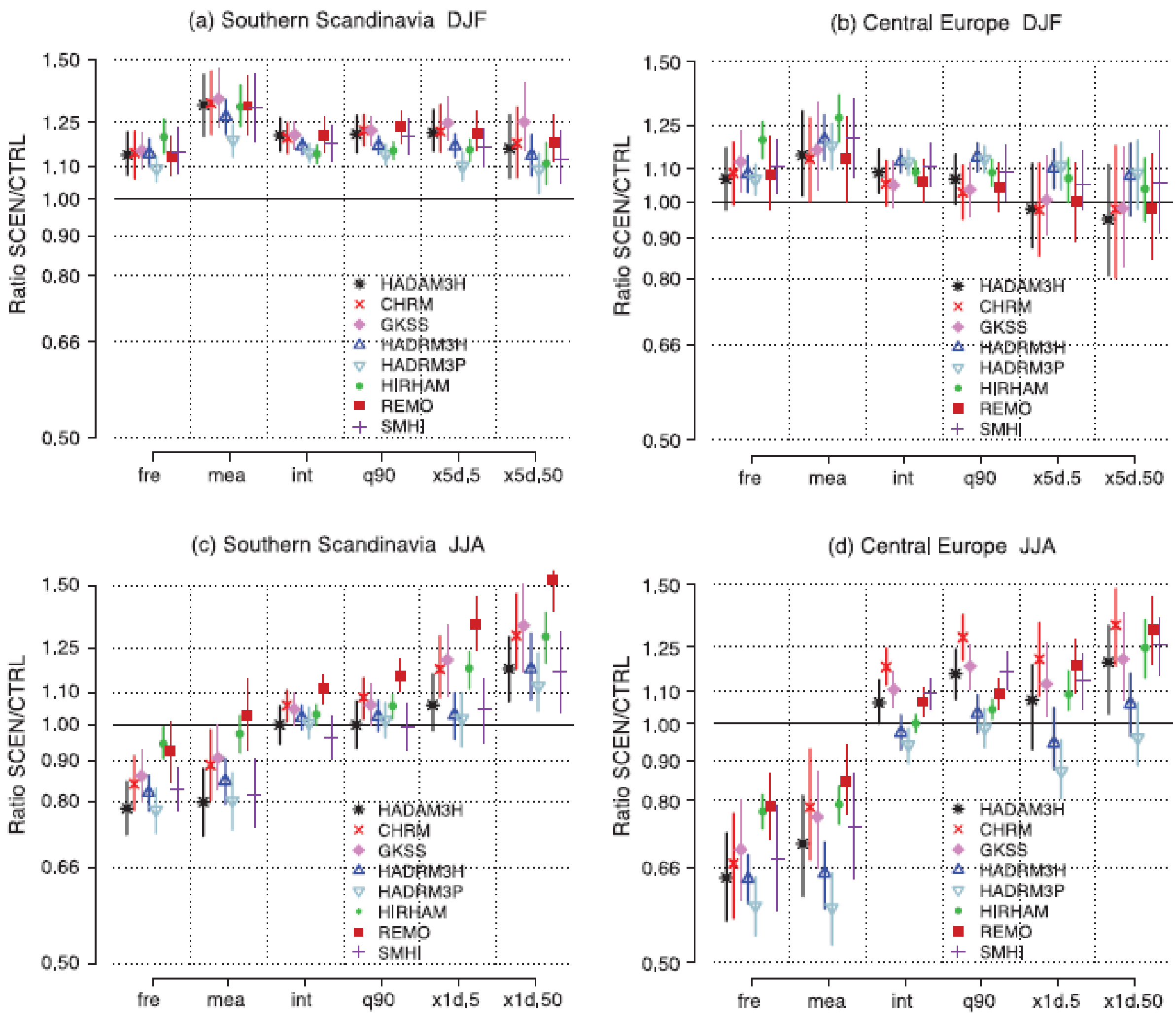

Figure 2: Variations in model predictions: Changes (ratio 2071–2100 / 1961–1990 for the A2 scenario) in domain-mean precipitation diagnostics in the PRUDENCE simulations in southern Scandinavia (5°E–20°E, 55°N–62°N) and central Europe (5°E–15°E, 48°N–54°N) in winter (top) and in summer (bottom). fre = wet-day frequency; mea = mean seasonal precipitation; int = mean wet-day precipitation; q90 = 90th percentile of wet-day precipitation; x1d.5 and x1d.50 = 5- and 50-year return values of one-day precipitation; x5d.5 and x5d.50 = 5- and 50-year return values of fi ve-day precipitation. For each of the eight models, the vertical bar gives the 95% confi dence interval associated with sampling uncertainty (redrawn from Frei et al., 2006). Models are the Hadley Centre Atmospheric Model (HadAM3H), the Climate High Resolution Model (CHRM), the climate version of the 'Lokalmodell' (CLM), the Hadley Centre Regional Model (HadRM3H and HadRM3P), the combination of the High-Resolution Limited Area Model (HIRLAM) and the European Centre Hamburg (ECHAM4) GCM (HIRHAM), the regional climate model REMO, and the Rossby Centre regional Atmosphere-Ocean model (RCAO). (Source: IPCC 2007 (1), p. 878)

2. Factor analysis on climate stimuli

1.1 Introduction

The 9 parameters derived from the CCLM model were used to calculate respective environmental change exposure indicators. The present exposure was calculated as the arithmetic mean of CCLM model runs for the time period 1961-1990, for example the present annual mean temperature was calculated as the mean of the three model run results of annual mean temperature for the time period 1961-1990.

The modeled time period was 2071-2100. The average of indicator values of the two CCLM model runs for the time period 2071-2100 considering the IPCC scenarios A1B and B1were used as predicted future indicator values.

Two kinds of change indicators were calculated: absolute changes ad relative changes. The absolute change indicators were calculated by subtracting the present indicator value (for example annual mean temperature) from the predicted future indicator value. Positive change means increasing annual mean temperature from present to the time period 2071-2100. The relative change indicators such as relative change in mean summer precipitation were calculated by dividing the absolute change by the present value. The relative changes have been presented as per cent changes (%).

The nine climate change exposure indicators were calculated as follows:

1. Absolute change in annual mean temperature

Tmean_change = Tmean (2071-2100) – Tmean (present)

2. Absolute change in annual number of frost days

FD_change = FD (2071-2100) – FD (present)

3. Absolute change in annual number of summer days

SD_change = SD (2071-2100) – SD (present)

4. Relative change in annual mean precipitation in winter months

Rw_change = [Rw (2071-2100) – Rw (present)]/Rw(present) x 100%

5. Relative change in annual mean precipitation in summer months

Rs_change = [Rs (2071-2100) – Rs (present)]/Rs(present) x 100%

6. Absolute change in annual number of days with heavy rainfall

R20mm_change = R20mm (2071-2100) – R20mm (present)

7. Relative change in mean annual surface runoff

SR_change = [SR (2071-2100) – SR (present)]/SR(present) x 100%

8. Relative change in mean annual evaporation

AEVAP_change = [AEVAP (2071-2100) – AEVAP (present)]/AEVAP(present) x 100%

9. Relative change in annual number of days with snow cover

SN_change = [SN (2071-2100) – SN (present)]/SN(present) x 100%

All the above mentioned change variables were calculated for two scenarios: A1B and B1.

The number of modeled cells was 42126. From those 21648 were located on land area. Only the land area cells are used for further investigations.

1.2 Discussion of CCLM Parameters

Change in annual mean temperature

Figure 1 shows the distribution of the first climate change exposure indicator ‘Change in annual mean temperature’ using scenario A1B. The changes are always positive from present to the time period 2071-2100 and the shape of the variable distribution is close to the normal distribution. The changes are smaller in scenario B1 (Fig.2). Both of these variables can be used in the factor analysis without any transformations.

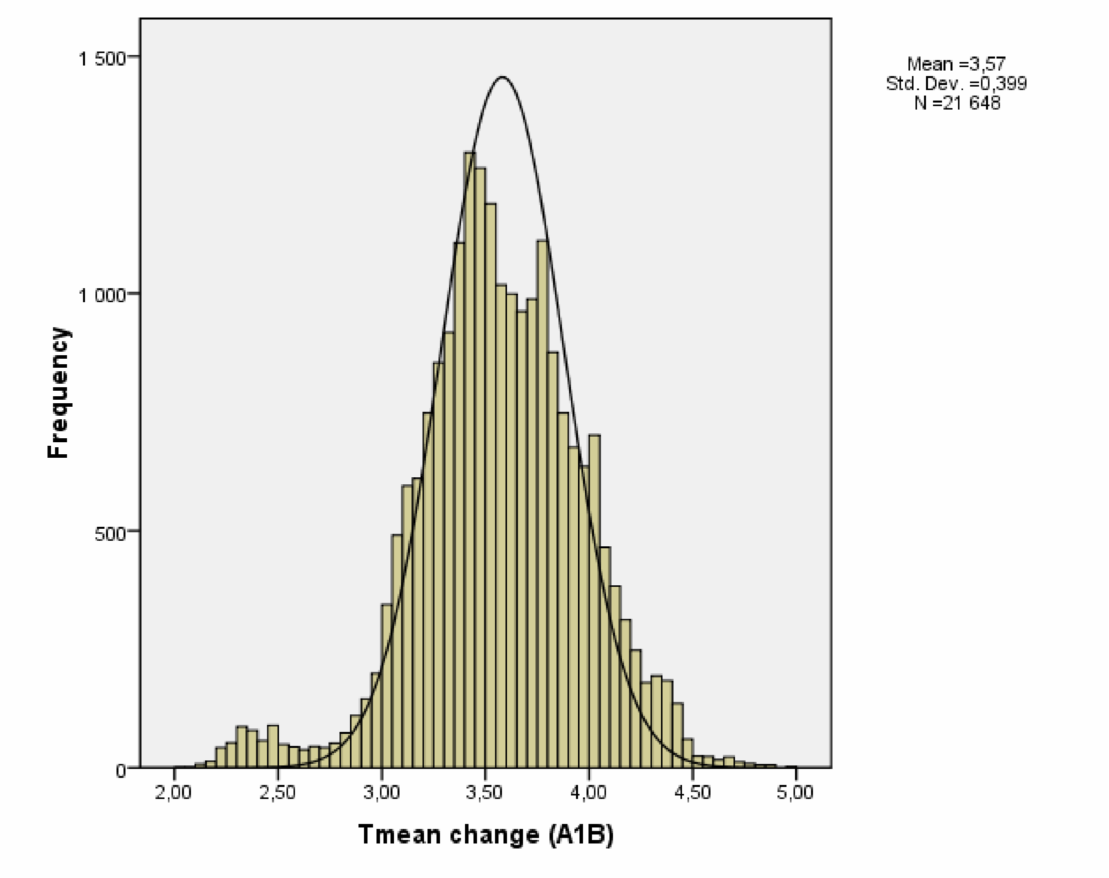

Fig. 1. Distribution of the change in annual mean temperature (^oC), scenario A1B.

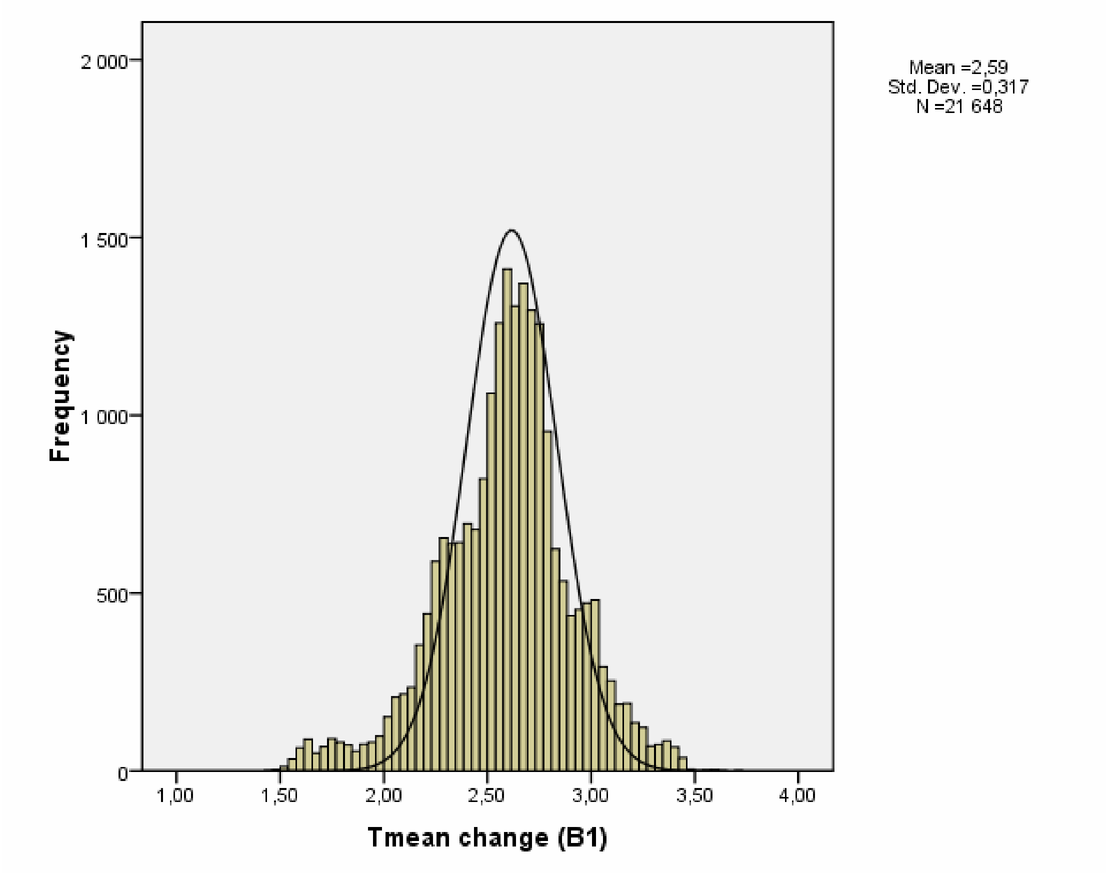

Fig. 2. Distribution of the change in annual mean temperature (^oC), scenario B1.

Change in annual number of frost days

Histogram in Figure 3 shows the distribution of ‘Change in annual number of frost days’ using scenario A1B. Changes are smaller if the calculations are based on scenario B1 (Fig. 4). Both of these variables show a skewed (lognormal) distribution. Both of these variables were Ln-transformed prior to the factor analysis. The minimum value was added to the original temperature change value before logarithm transformation to achieve positive values. For example, the minimum value for the absolute change in annual number of frost days, scenario A1B, was -81, and the ln-transformed variable to be applied in the factor analysis was calculated as follows

Ln_FD_change = Ln(FD_change + 81)

The distributions of the Ln-transformed variables are shown in figures 5 and 6.

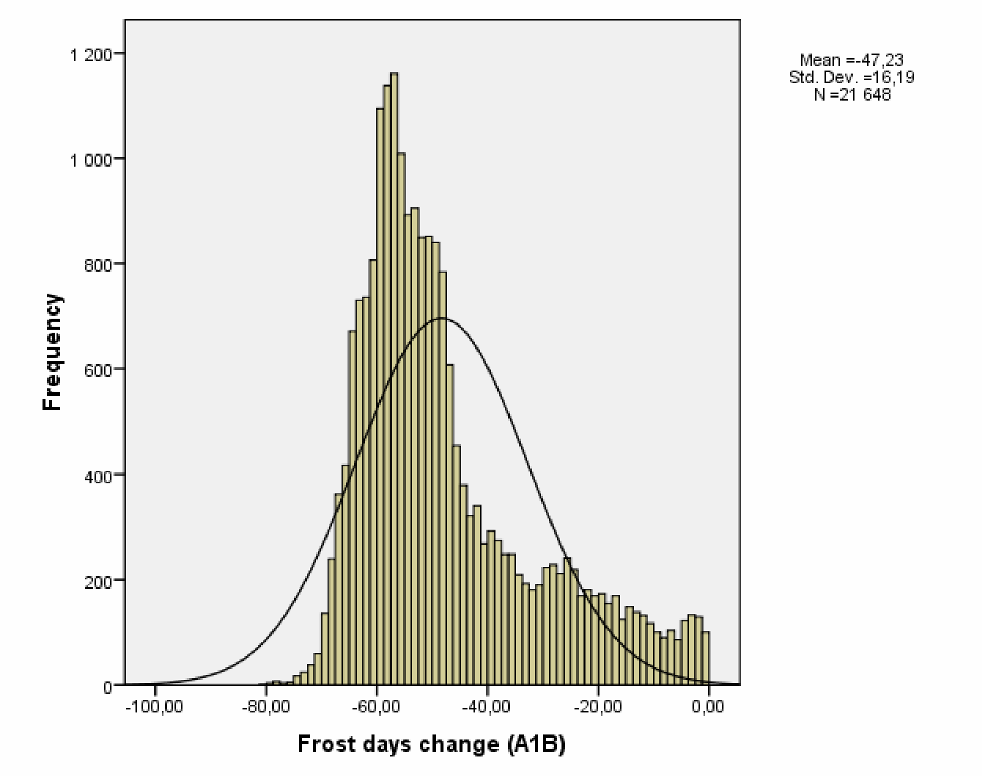

Fig. 3. Distribution of 'Absolute change in annual number of frost days'. Scenario A1B

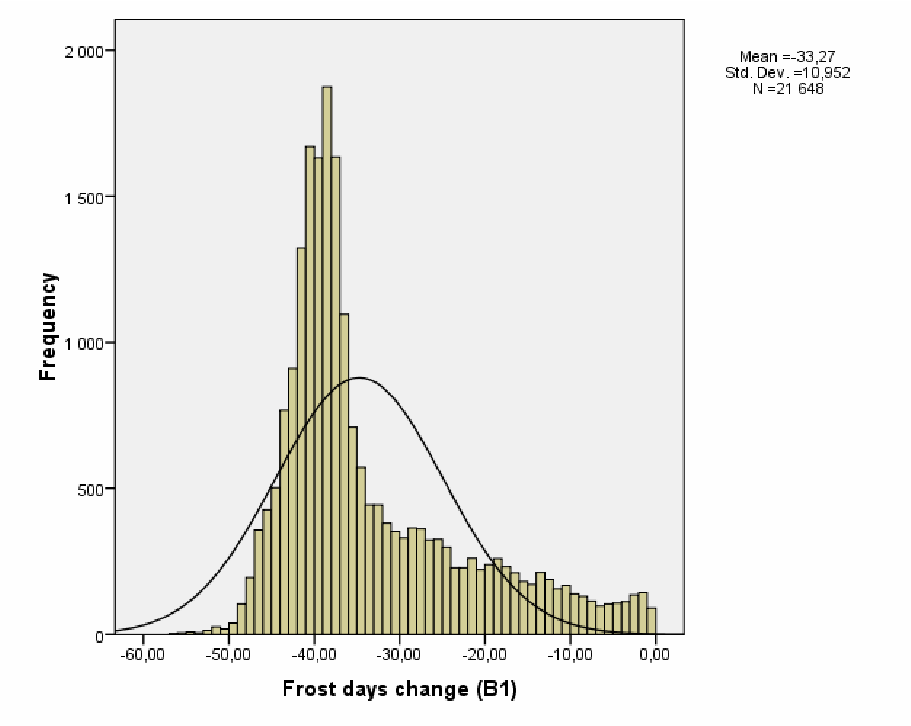

Fig. 4. Distribution of 'Absolute change in annual number of frost days'. Scenario B1.

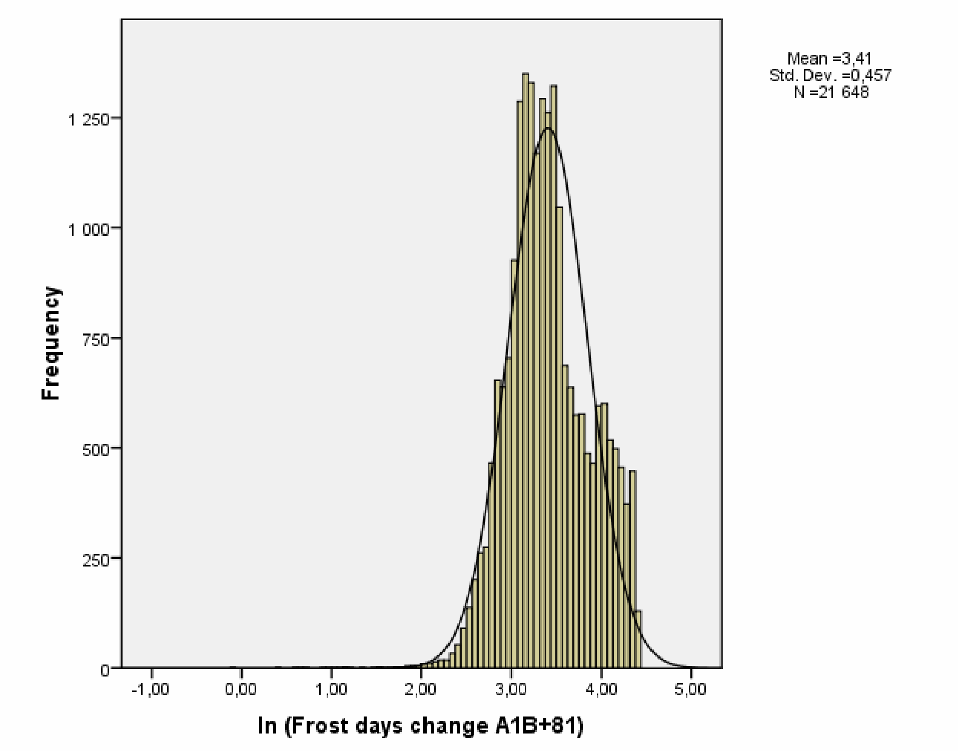

Fig. 5. Distribution of Ln-transformed variable 'Absolute change in annual number of frost days'. Scenario A1B

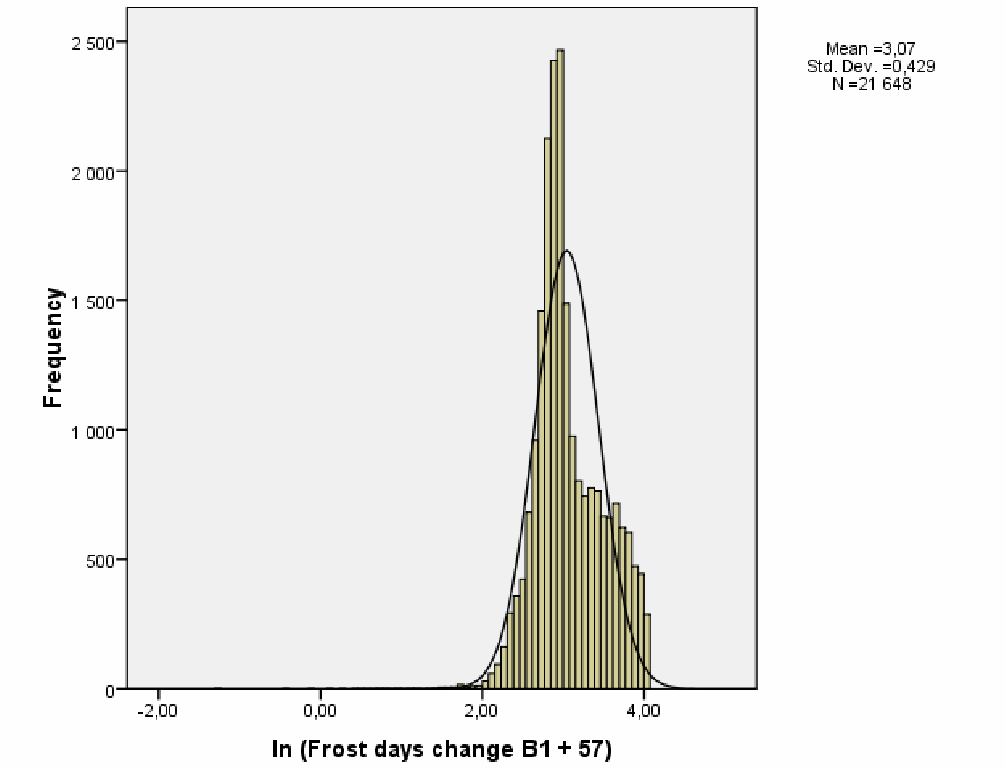

Fig. 6. Distribution of Ln-transformed variable 'Absolute change in annual number of frost days'. Scenario B1

Annual number of summer days

Distribution of the change in annual number of summer days (scenario A1B) is shown in figure 7. This variable has a bimodal distribution also in scenario B1 (Fig- 8). Fig. 9. shows that the low values are located in the North Europe.

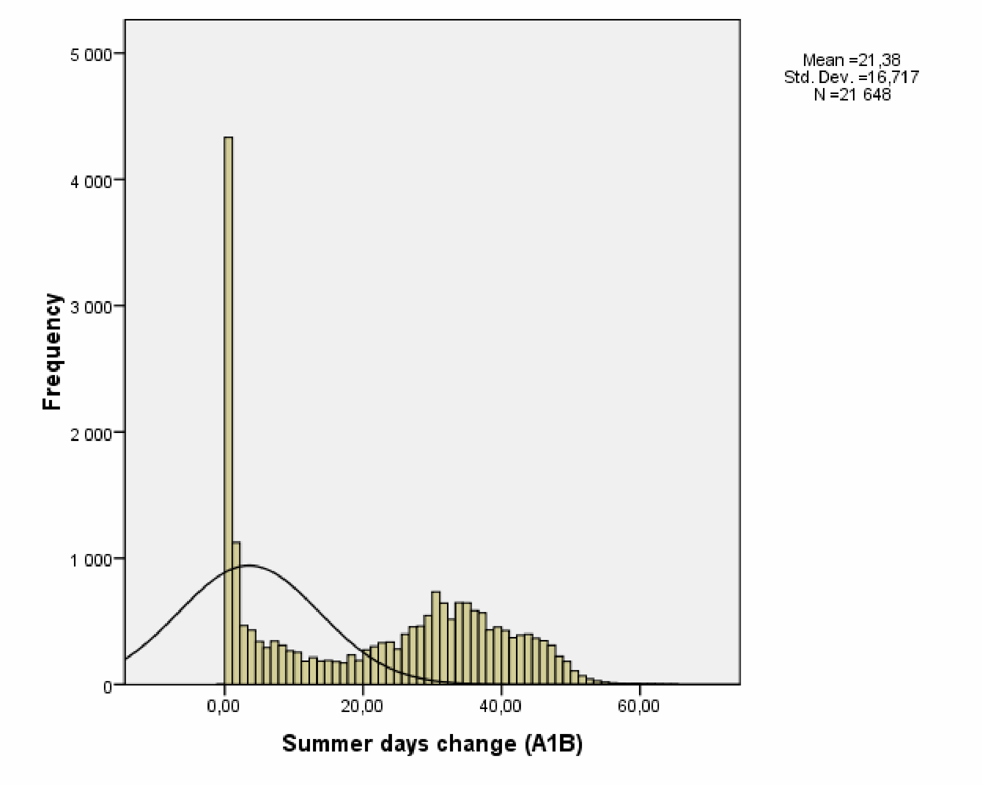

Fig. 7. Distribution of the change in annual number of summer days (scenario A1B).

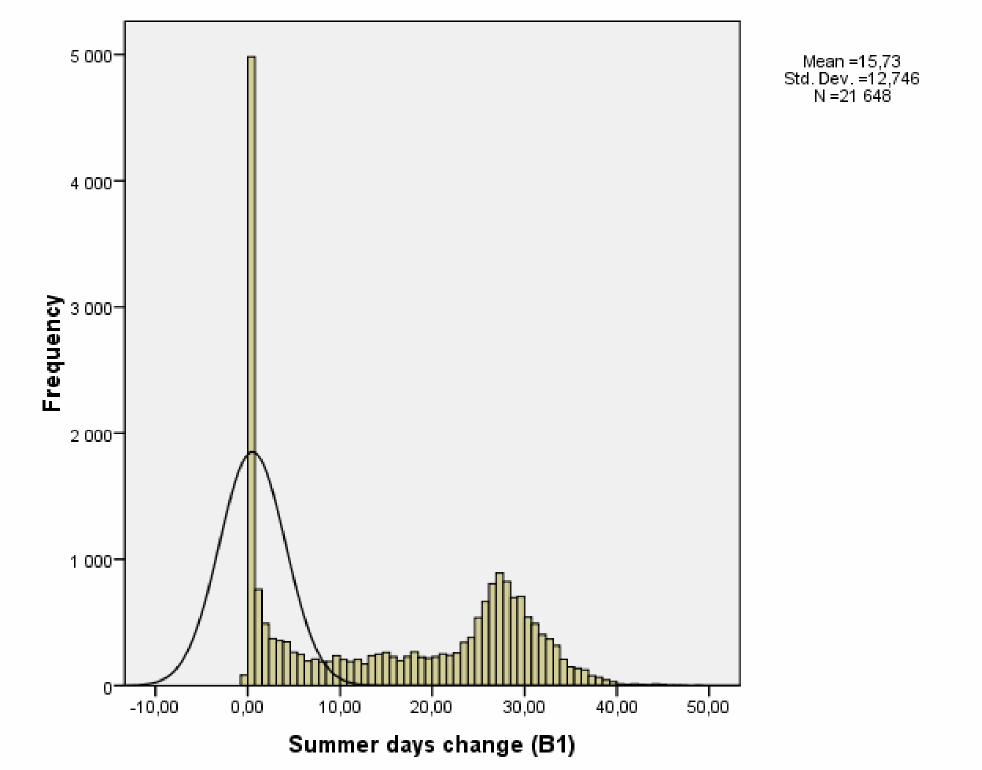

Fig. 8. Distribution of the change in annual number of summer days (scenario B1).

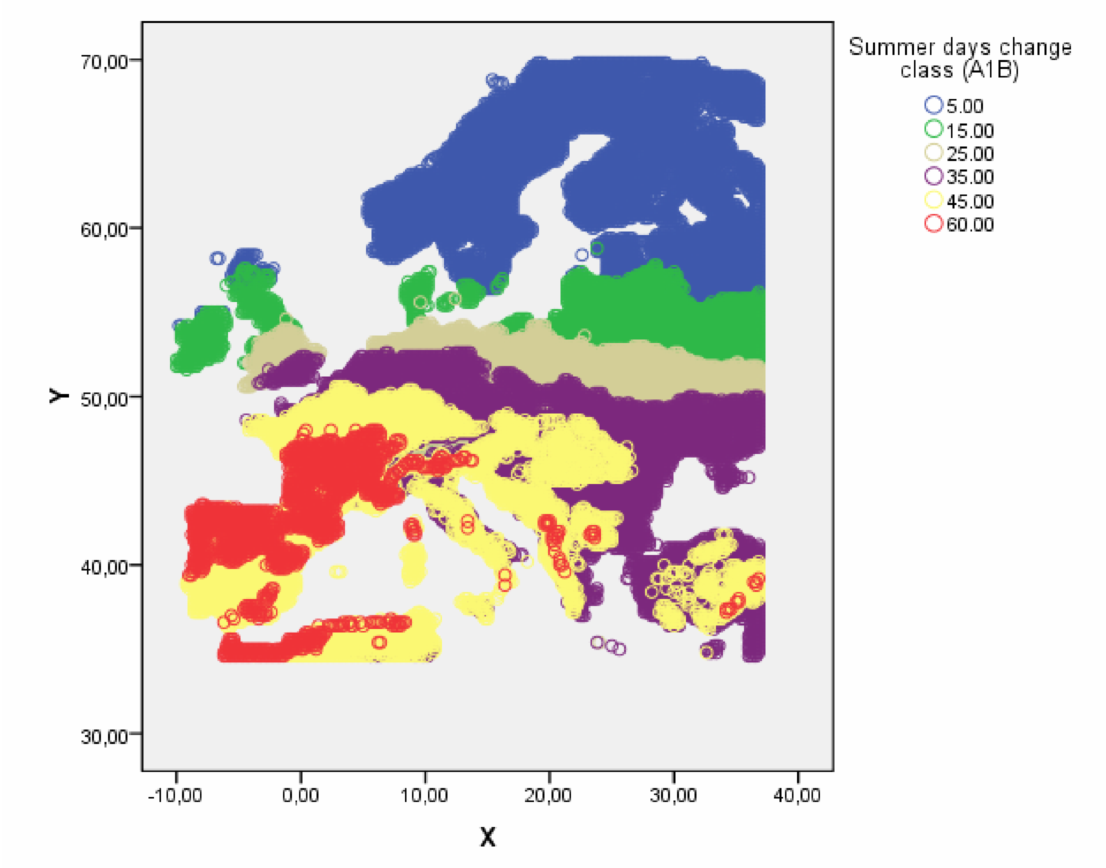

Fig. 9. Simplified map of the distribution of the change in annual number of summer days (scenario A1B).

Table 1. Pearson's correlation coefficients for cells with calculated summer days change > 5. Number of pairs 15131. ** = correlation is significant at at the 0.01 level (2-tailed).

	Summer days change (A1B)
Tmean change (A1B)	,593**
Frost days change (A1B)	,547**
Heavy rainfall change (A1B)	-,402**
Snow cover change (A1B)	,545**
Summer rain change % (A1B)	-,763**
Winter rain change % (A1B)	-,547**
Surface runoff change % (A1B)	,324**
Evaporation change % (A1B)	-,518**

A strongly bimodal variable can be problematic for factor analysis. When the low summer days change values of the North Europe are omitted from the dataset, the summer days change variable shows significant positive correlation with Tmean change, frost days change, snow cover change and surface runoff change and significant negative correlation with heavy rainfall change, summer rain change, winter rain change and evaporation change. Figure10 shows the correlation between the relative summer rain change and the absolute number of summer days change in the whole data set. If the number of summer days change is almost zero (north Europe), the relative change in summer rain can be either positive or negative. When the estimated increase in the number of summer days is over 5, there is a clear correlation between the variables: the summer rain will decrease when the number of summer days increase.

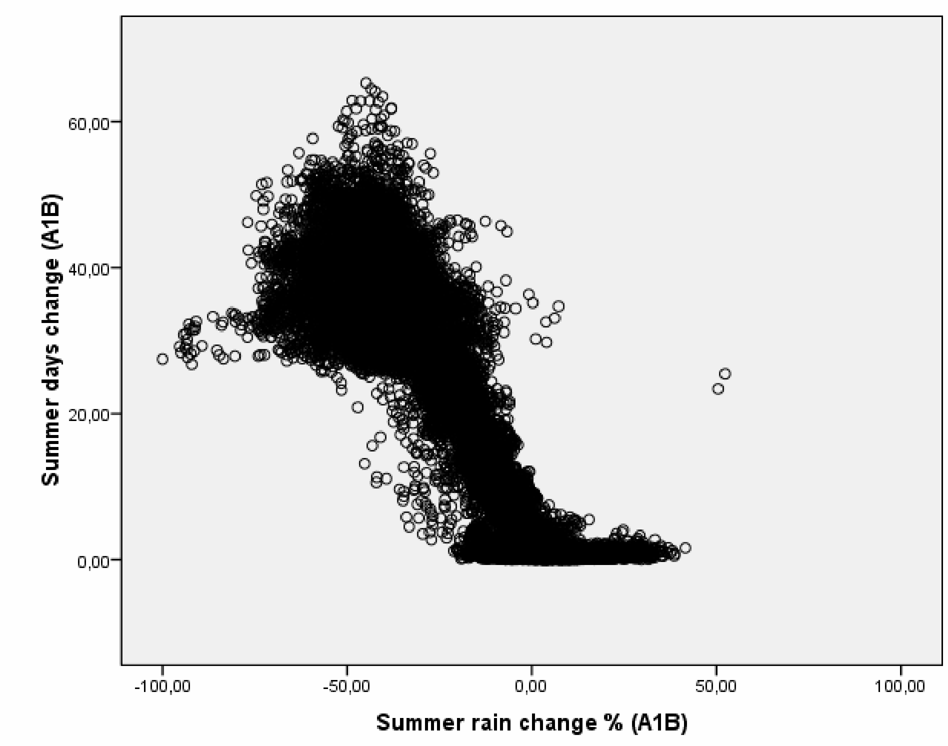

Fig. 10. Scatter diagram of the relative summer rain change (x-axis) and the absolute summer days change, scenario A1B.

Annual mean precipitation in winter months

Figures 11 and 12 show the distribution of the relative change in annual mean precipitation in winter months using scenarios A1B and B1, respectively. The relative changes in annual mean precipitation in winter months variables show negative skewness. New Ln-transformed variables were calculated for factor analysis as follows

Ln_Rw_change (scenario A1B) = Ln(47- Rw_change) and

Ln_Rw_change (scenario B1) = Ln(27- Rw_change)

These formulas will change the direction of the variable, thus a relative increase in winter rain will be a negative change in the new variable. The distributions of the Ln-transformed variables are shown in figures 13 and 14.

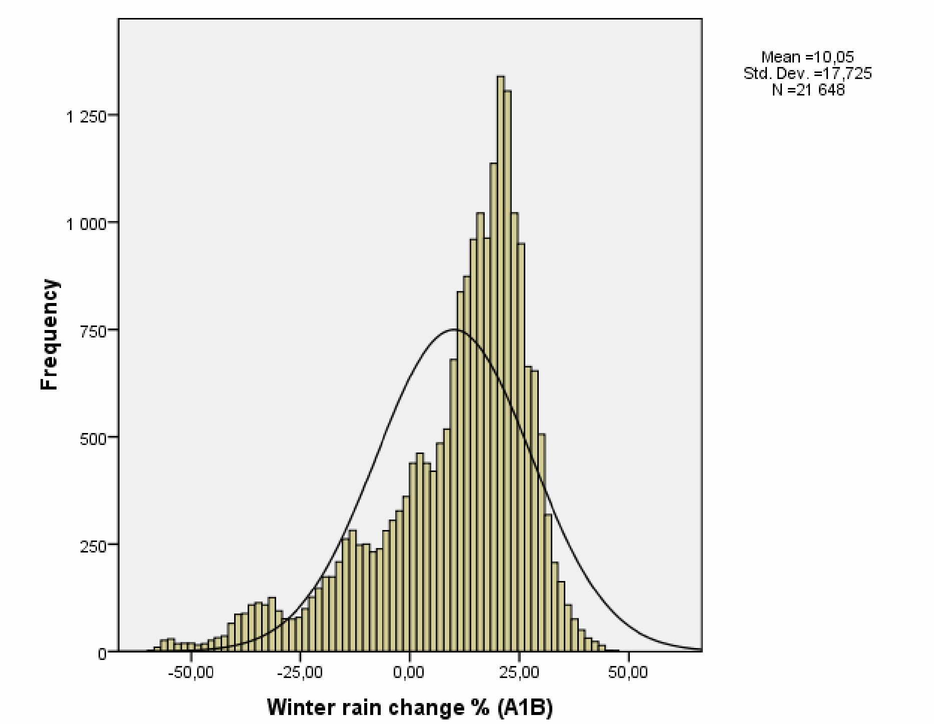

Fig 11.Distribution of the relative change in annual mean precipitation in winter months (scenario A1B).

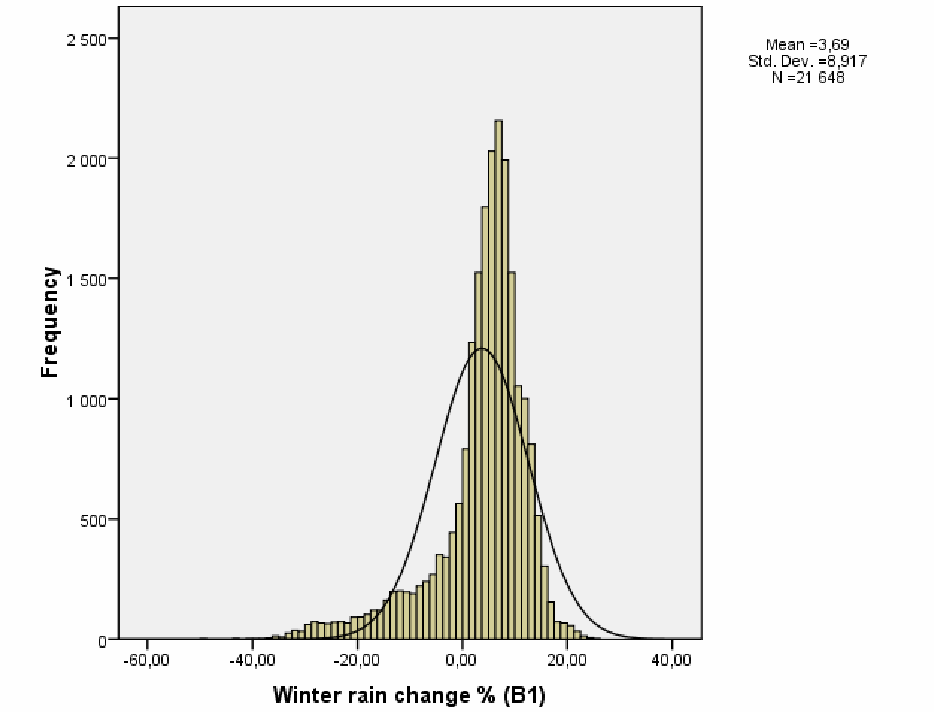

Fig .12.Distribution of the relative change in annual mean precipitation in winter months (scenario B1).

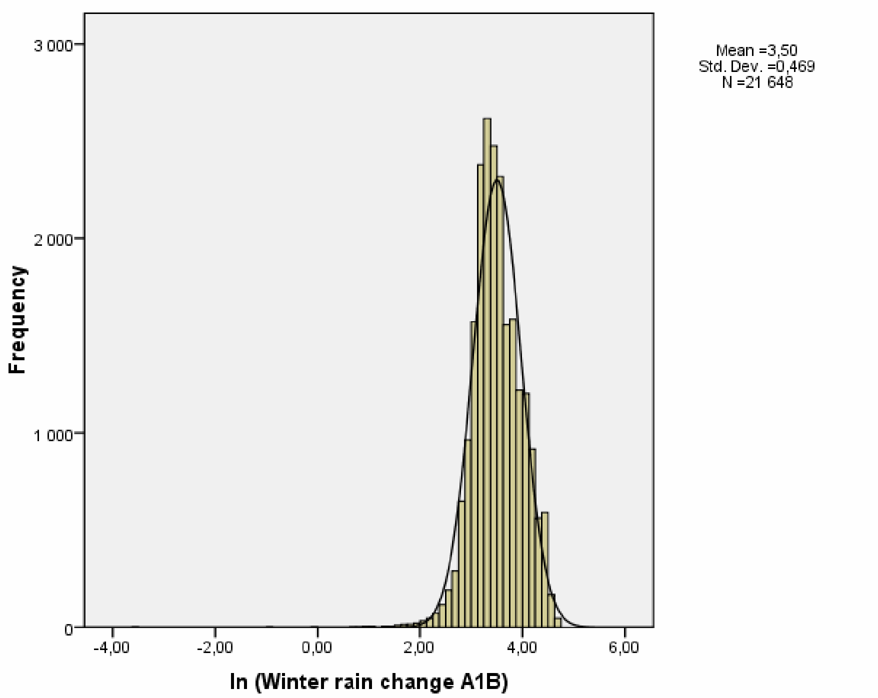

Fig 13.Distribution of the Ln-transformed variable (47 - relative change in annual mean precipitation in winter months) (scenario A1B).

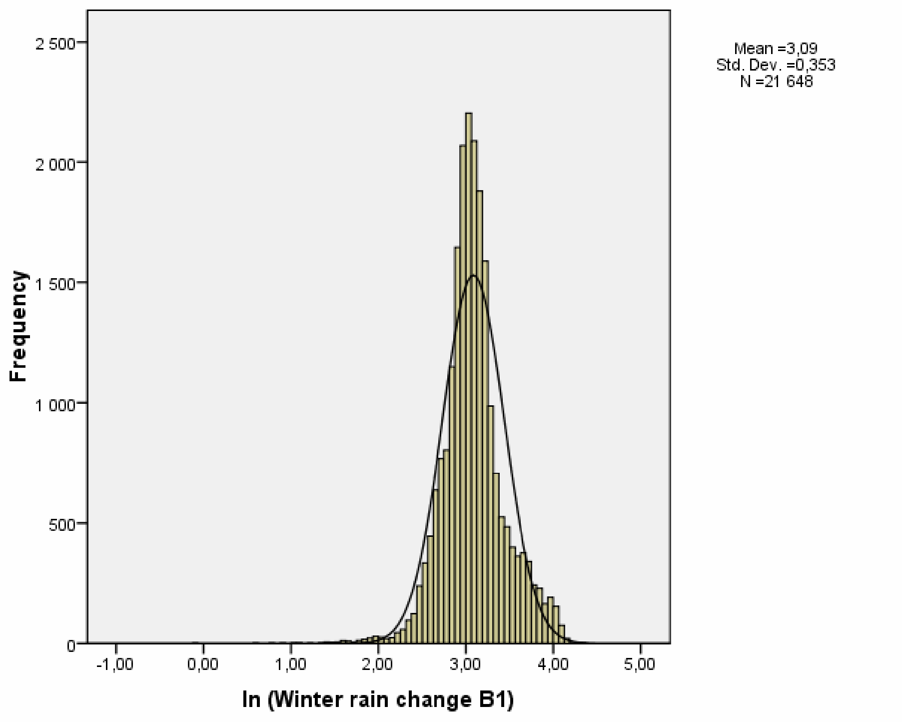

Fig .14.Distribution of the Ln-transformed variable (27 - relative change in annual mean precipitation in winter months) (scenario B1).

Annual mean precipitation in summer months
The relative change in annual mean precipitation in summer months if shown in figures 15 and 16. These variables have more symmetrical distributions.than the winter rain change variables.

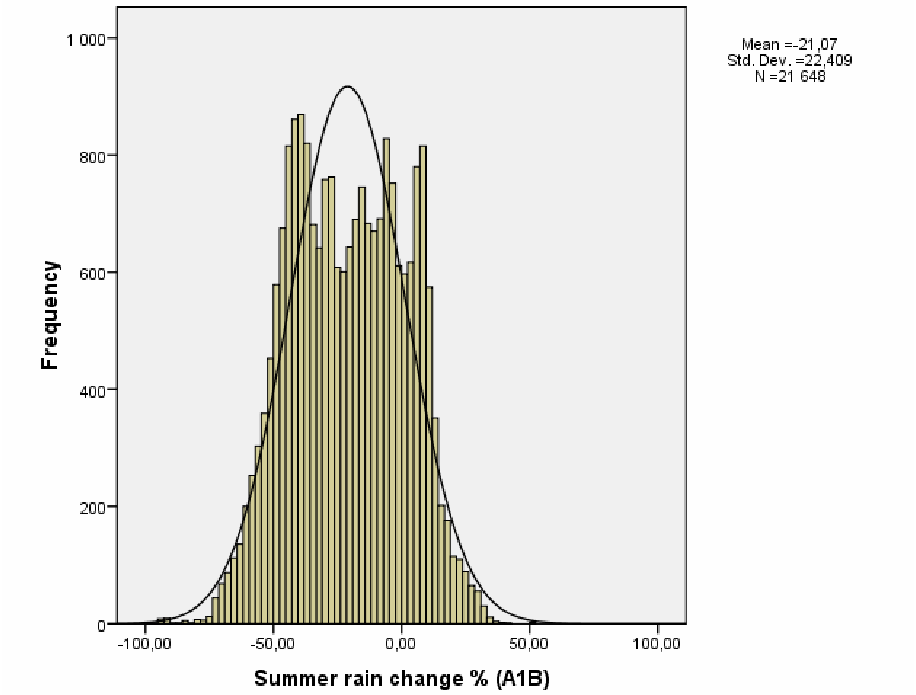

Fig 15. Distribution of the relative change in annual mean precipitation in summer months.(scenario A1B)

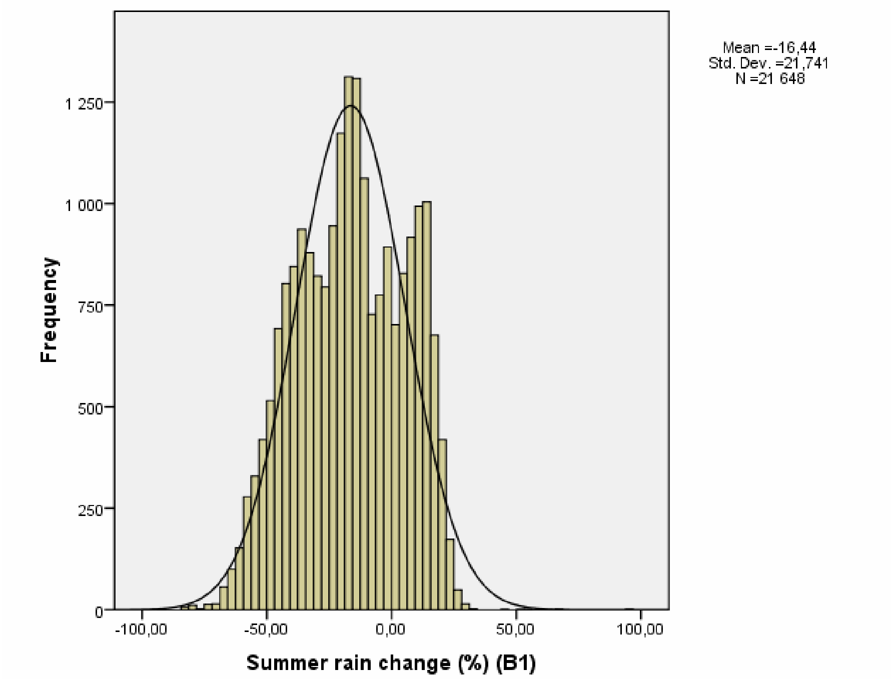

Fig 16. Distribution of the relative change in annual mean precipitation in summer months.(scenario B1)

Heavy rainfall
Change in annual number of days with heavy rainfall is presented in the histogram of figures 17 and 18. These symmetrical variables were used in the factor analysis.

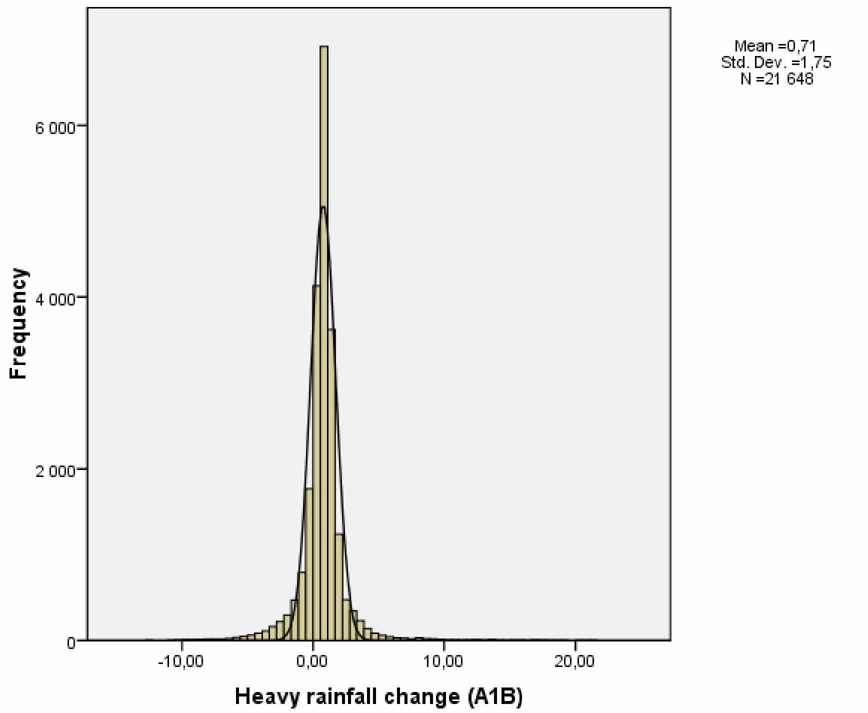

Fig .17. Distribution of the change in annual number of days with heavy rainfall (scenario A1B).

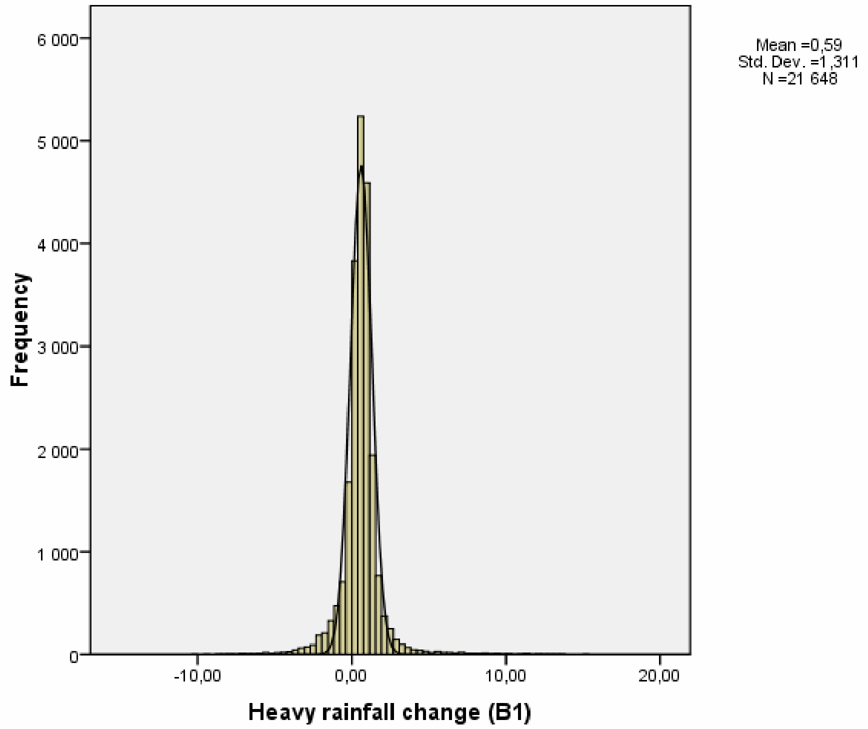

Fig .18. Distribution of the change in annual number of days with heavy rainfall (scenario B1).

Mean annual surface runoff
Figures 19 and 20 show the distribution of the relative change in mean annual surface runoff using scenarios A1B and B1, respectively. The former distribution is positively skew, and a Ln-transformed variable was calculated as follows:

Ln_SR_change (scenario A1B) = Ln(SR_change + 82)

The distribution of the new calculated transformed variable is shown in figure 21.

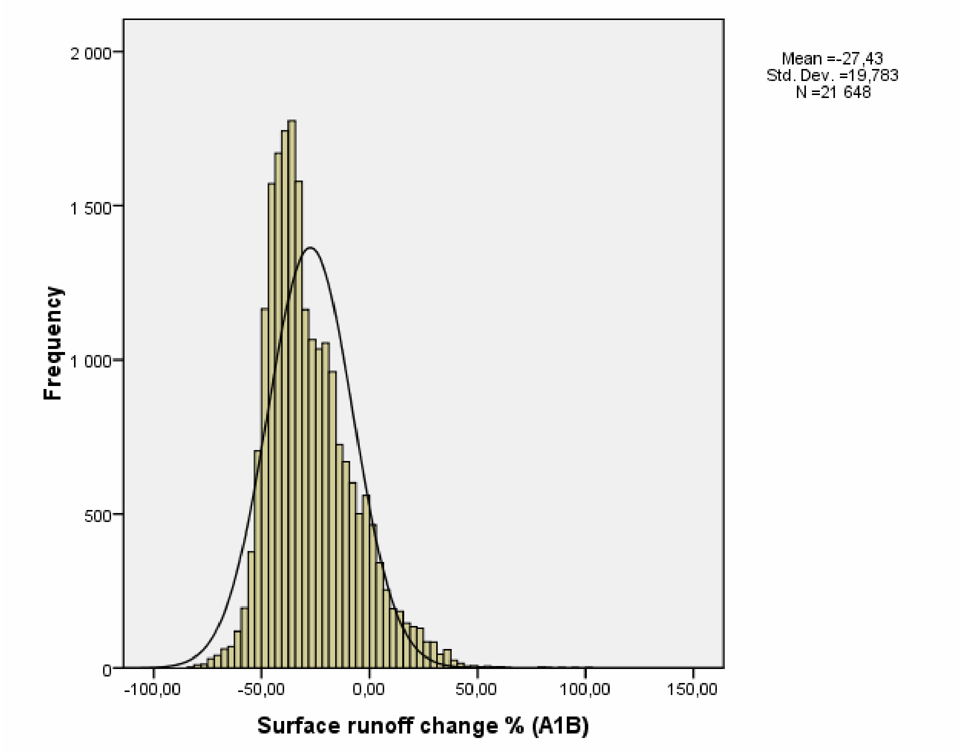

Fig 19. Distribution of the relative change in mean annual surface runoff.(scenario A1B)

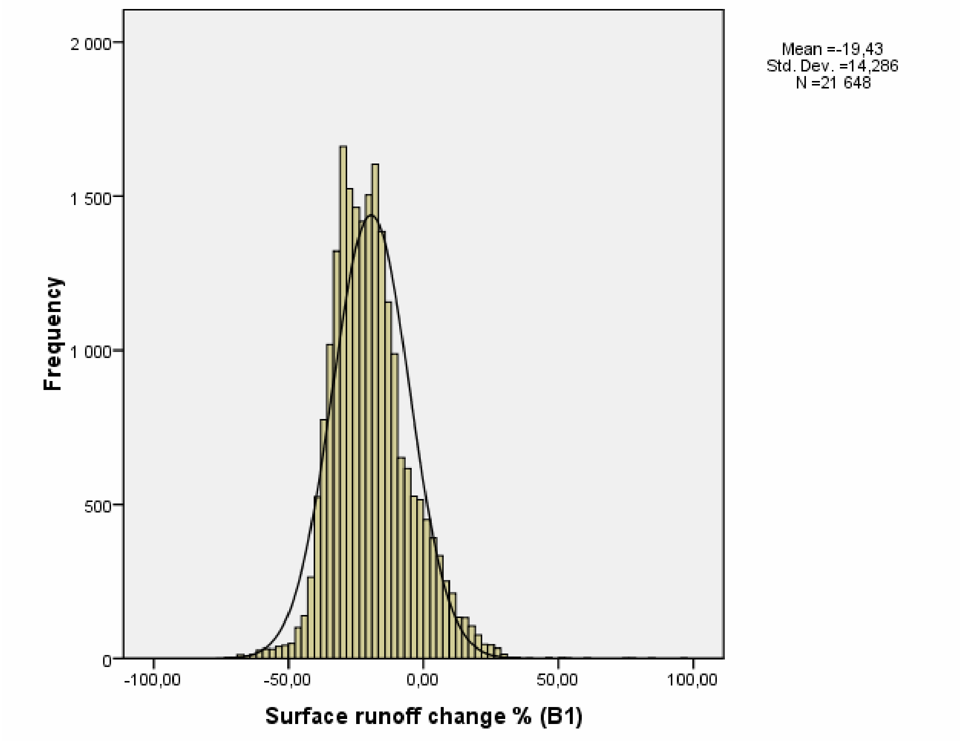

Fig 20. Distribution of the relative change in mean annual surface runoff.(scenario B1)

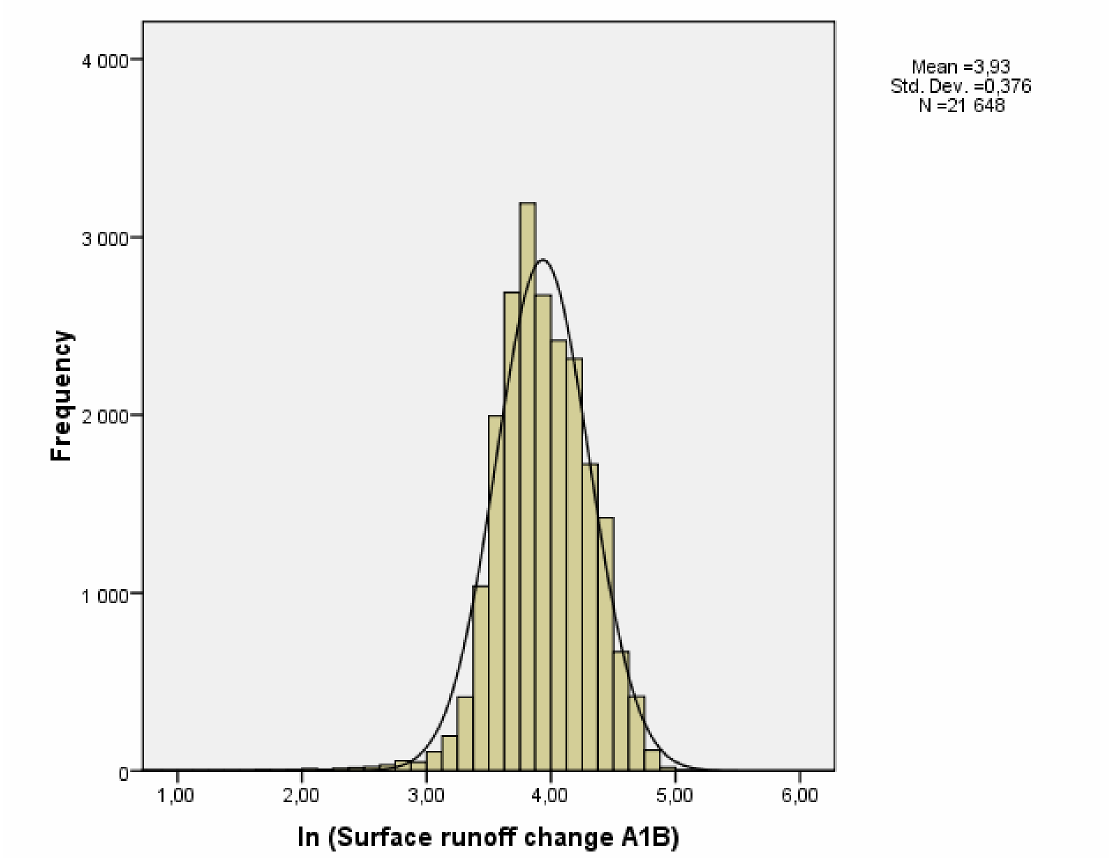

Fig 21. Distribution of the Ln-transformed variable relative change in mean annual surface runoff.(scenario A1B). Not all the smallest values shown, minimum -2.5.

Mean annual evaporation

Figures 22 and 23 show the distribution of the relative change in mean annual evaporation using scenarios A1B and B1, respectively. Both of these variables are negatively skewed. New Ln-transformed variables were calculated for factor analysis as follows

Ln_AEVAP_change (scenario A1B) = Ln(57- AEVAP_change) and

Ln_AEVAP_change (scenario B1) = Ln(48- AEVAP_change)

These formulas will change the direction of the variable, thus a relative increase in evaporation will be a negative change in the new variable. The distributions of the Ln-transformed variables are shown in figures 24 and 25.

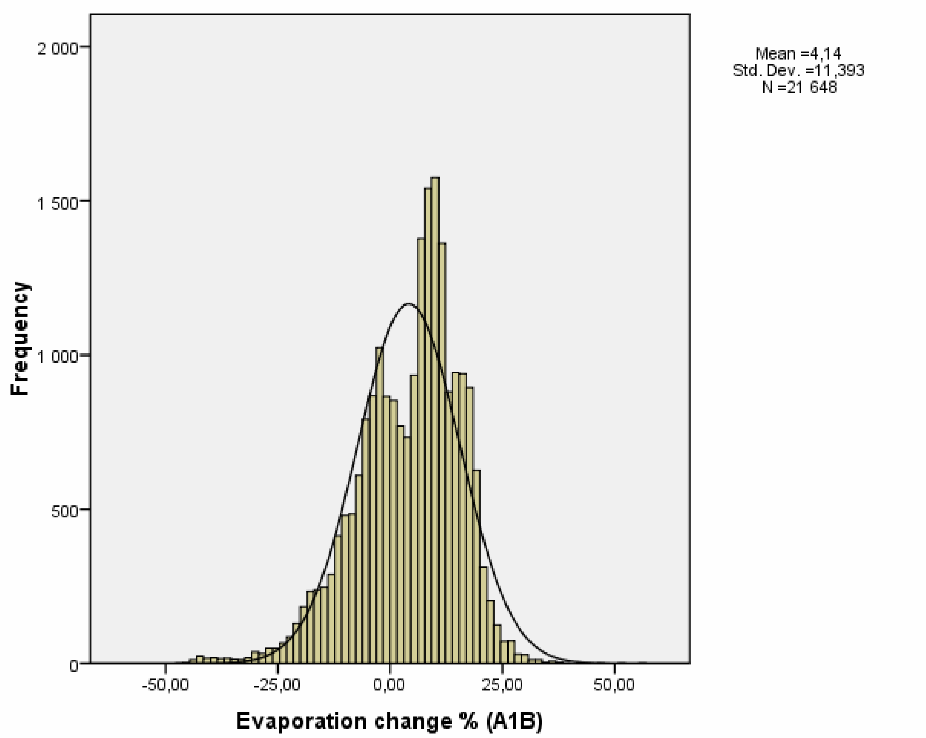

Fig 22. Distribution of the relative change in mean annual evaporation.(scenario A1B)

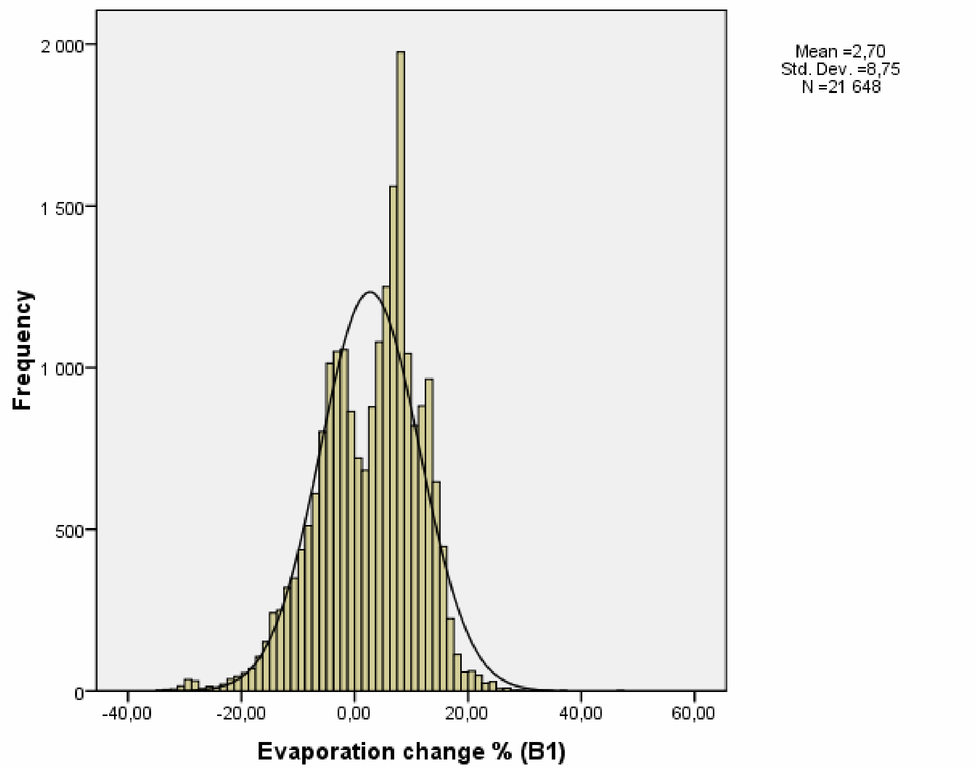

Fig 23. Distribution of the relative change in mean annual evaporation.(scenario B1)

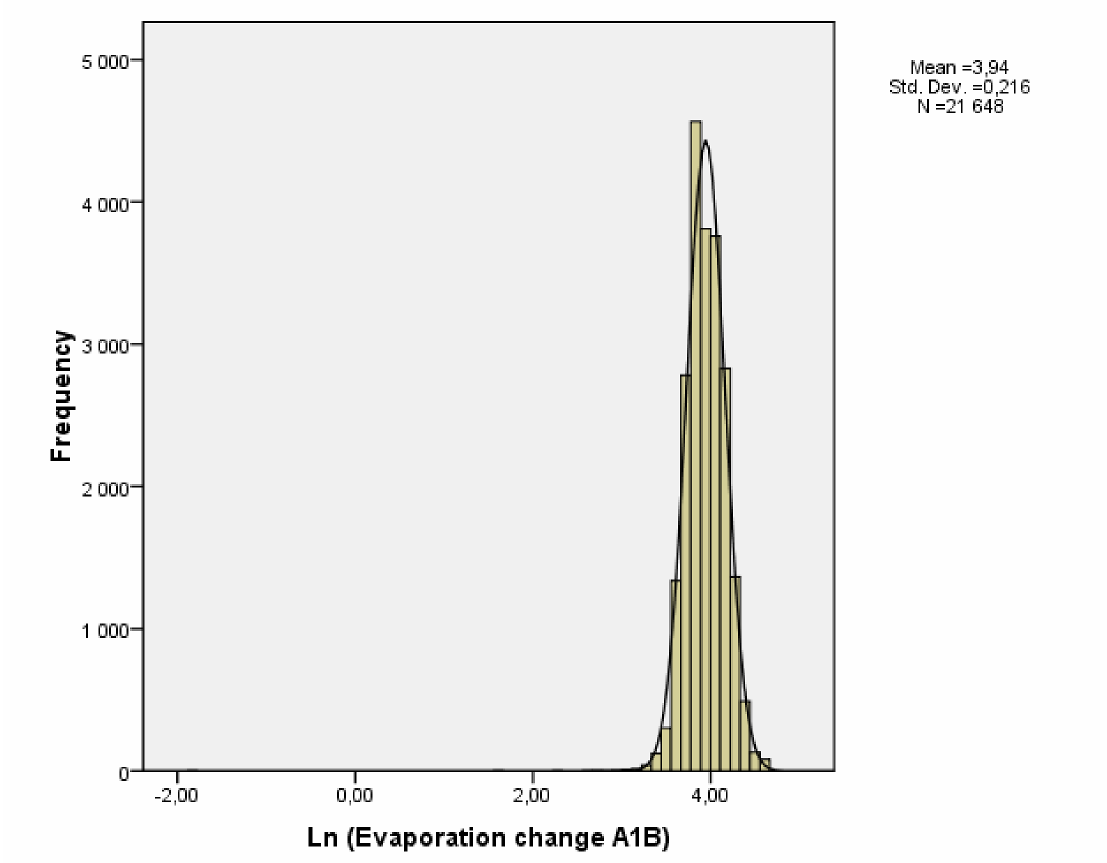

Fig. 24.Distribution of the Ln-transformed variable (47 - relative change in annual evaporation) (scenario A1B).

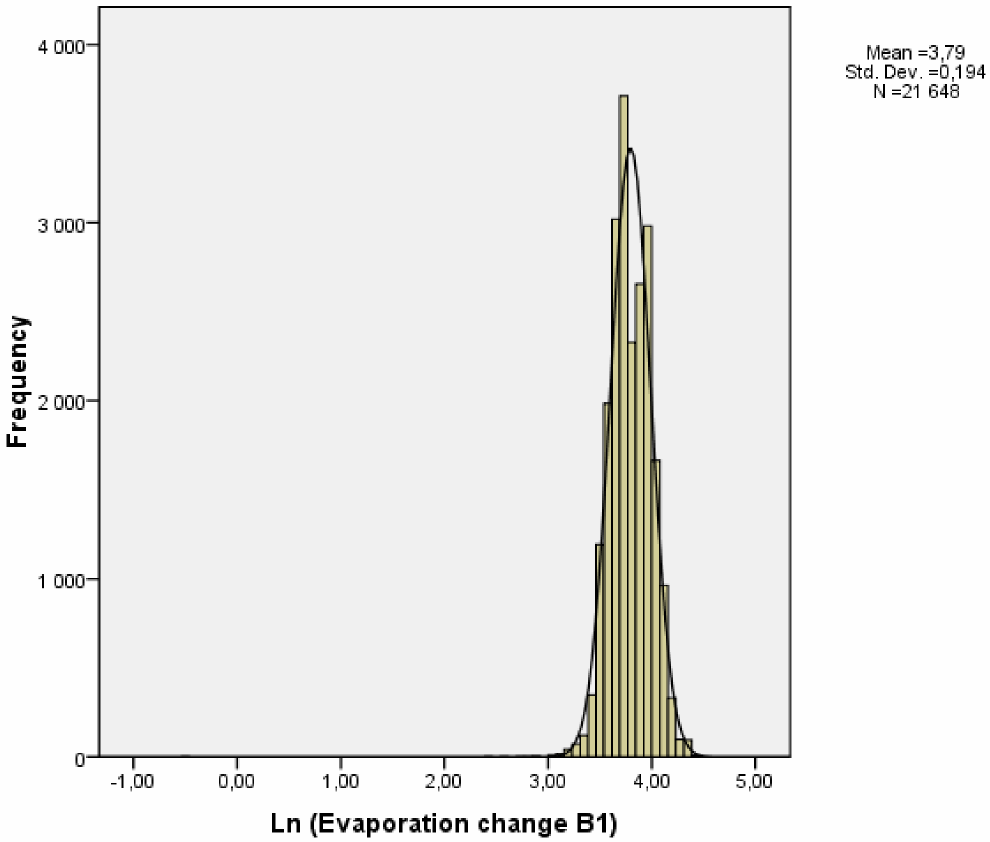

Fig. 25.Distribution of the Ln-transformed variable (47 - relative change in annual evaporation) (scenario B1).

Snow cover

Figures 26 and 27 show the distribution of the absolute change in annual number of days with snow cover using scenarios A1B and B1, respectively. Both of these variables show a bimodal distribution. In some parts of Europe the absolute change in annual number of days with snow cover is almost zero, while other areas show decrease of ca. 40-60 days.

Figure 28 presents a simplified map of classified scenario A1B values. In most of Europe the decrease of the days will be between 0 and 20 days/year. Bigger values are valid for North and North-East Europe and the Alps. Table 2 shows the correlation with other variables in the areas with major changes (decrease in the number of days more than 20 days).

Similar to the annual number of summer days, this variable with bimodal distribution can be problematic for factor analysis.

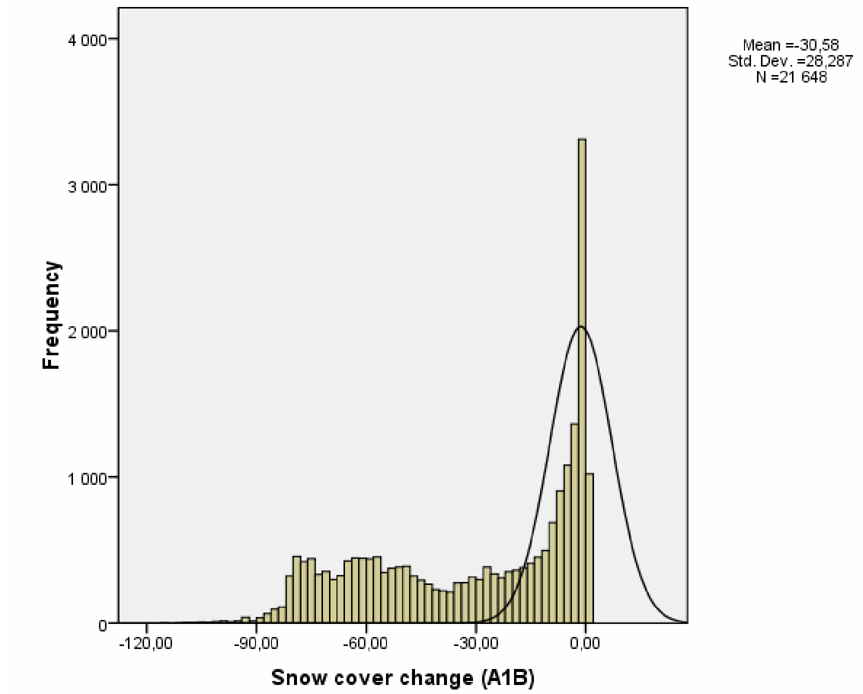

Fig 26. Distribution of the absolute change in annual number of days with snow cover (scenario A1B)

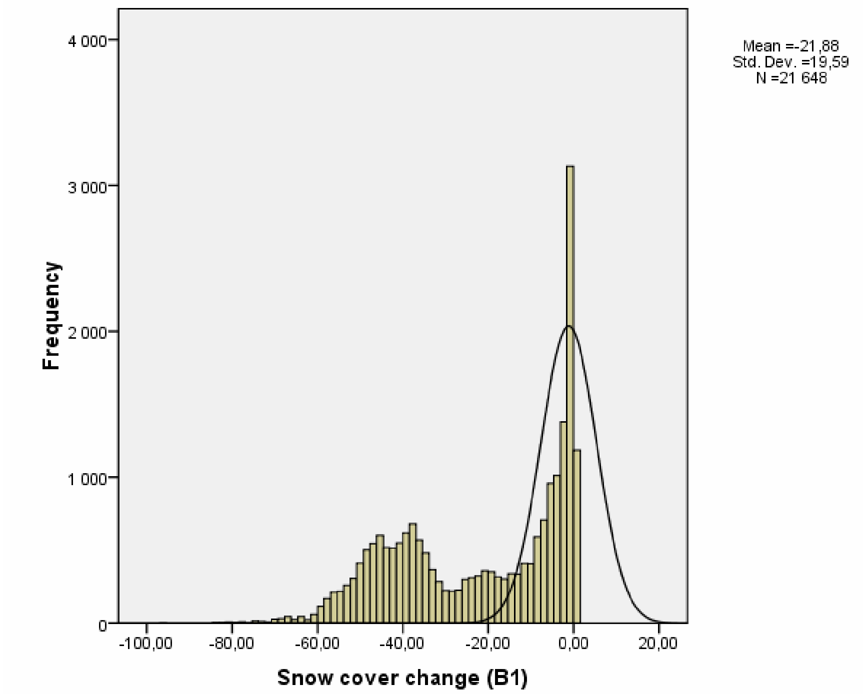

Fig 27. Distribution of the absolute change in annual number of days with snow cover (scenario B1)

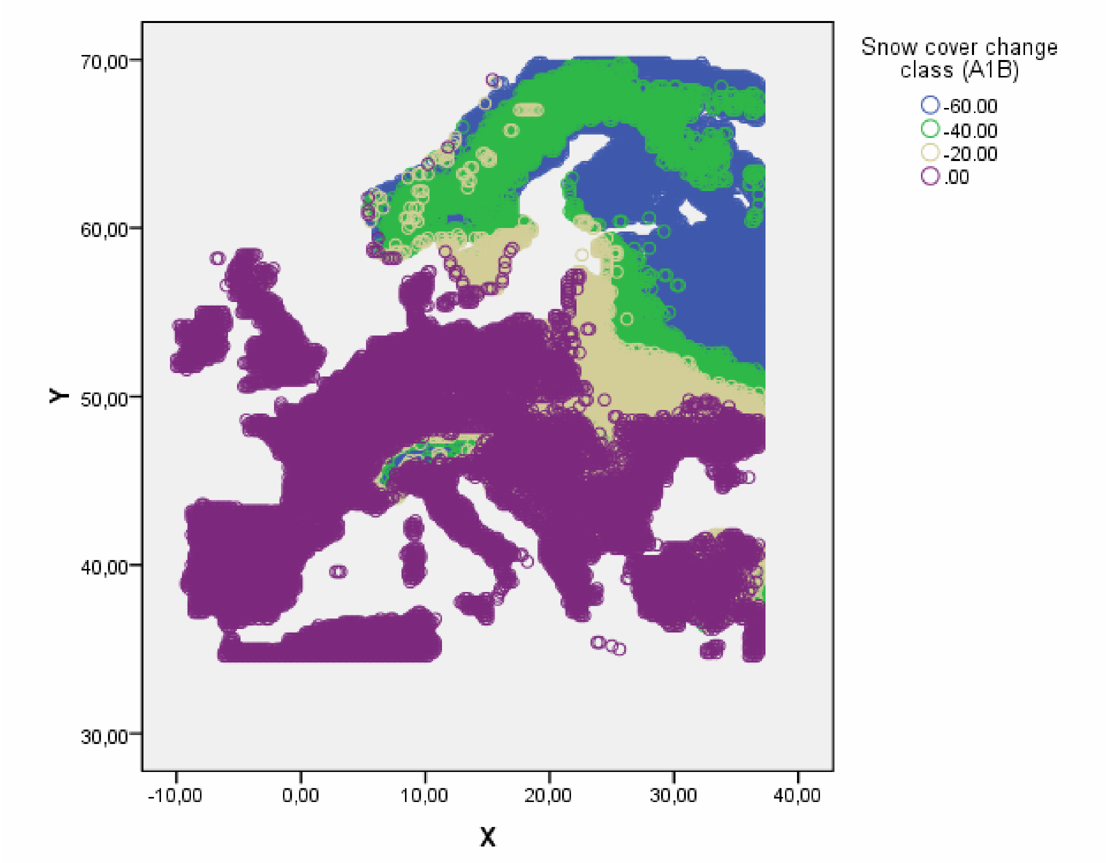

Fig. 28. Simplified map of the absolute change in annual number of days with snow cover (scenario A1B). In most of Europe the decrease of the days will be between 0 and 20 days/year.

Table 2. Pearson's correlation coefficients for cells with calculated snow cover days change < -20. Number of pairs 11188. ** = correlation is significant at the 0.01 level (2-tailed).

	Snow cover change (A1B)
Tmean change (A1B)	-,435**
Frost days change (A1B)	,223**
Summer days change (A1B)	,544**
Heavy rainfall change (A1B)	-,180**
Summer rain change % (A1B)	-,537**
Winter rain change % (A1B)	-,087**
Surface runoff change % (A1B)	-,090**
Evaporation change % (A1B)	-,391**

1.3 Suggested indicator variables for factor analysis

The following climate change variables are suggested for factor analysis of the A1B scenario data set:

1. Absolute change in annual mean temperature

Tmean_change = Tmean (2071-2100) – Tmean (present)

2. Ln-transformed variable Absolute change in annual number of frost days

Ln_FD_change = Ln(FD (2071-2100) – FD (present) + 81)

3. Ln-transformed variable Relative change in annual mean precipitation in winter months (Direction changed)

Ln_Rw_change = Ln(47 - [Rw (2071-2100) – Rw (present)]/Rw(present) x 100%)

4. Relative change in annual mean precipitation in summer months

Rs_change = [Rs (2071-2100) – Rs (present)]/Rs(present) x 100%

5. Absolute change in annual number of days with heavy rainfall

R20mm_change = R20mm (2071-2100) – R20mm (present)

6. Ln-transformed variable Relative change in mean annual surface runoff

Ln_SR_change = Ln ([SR (2071-2100) – SR (present)]/SR(present) x 100%)

7. Ln-transformed variable Relative change in mean annual evaporation (Direction changed)

AEVAP_change = Ln (57 - [AEVAP (2071-2100) – AEVAP (present)]/AEVAP(present) x 100%)

The following variables should be separately evaluated in the evaluation of the factor analysis:

1. Absolute change in annual number of summer days

SD_change = SD (2071-2100) – SD (present)

2. Relative change in annual number of days with snow cover

SN_change = [SN (2071-2100) – SN (present)]/SN(present) x 100%

The following climate change variables are suggested for factor analysis of the B1 scenario data set:

1. Absolute change in annual mean temperature

Tmean_change = Tmean (2071-2100) – Tmean (present)

2. Ln-transformed variable Absolute change in annual number of frost days

Ln_FD_change = Ln(FD (2071-2100) – FD (present) + 57)

3. Ln-transformed variable Relative change in annual mean precipitation in winter months (Direction changed)

Ln_Rw_change = Ln(27 - [Rw (2071-2100) – Rw (present)]/Rw(present) x 100%)

4. Relative change in annual mean precipitation in summer months

Rs_change = [Rs (2071-2100) – Rs (present)]/Rs(present) x 100%

5. Absolute change in annual number of days with heavy rainfall

R20mm_change = R20mm (2071-2100) – R20mm (present)

6. Relative change in mean annual surface runoff

SR_change = [SR (2071-2100) – SR (present)]/SR(present) x 100%

7. Ln-transformed variable Relative change in mean annual evaporation (Direction changed)

AEVAP_change = Ln (48 - [AEVAP (2071-2100) – AEVAP (present)]/AEVAP(present) x 100%)

The following variables should be separately evaluated in the evaluation of the factor analysis:

1. Absolute change in annual number of summer days

SD_change = SD (2071-2100) – SD (present)

2. Relative change in annual number of days with snow cover

SN_change = [SN (2071-2100) – SN (present)]/SN(present) x 100%

1.4 Analysis results

A1B scenario

Factor analysis is used to reduce the number of studied variables and to find few common factors behind the measured variables. These factors will be able to explain most of the variation in the whole dataset. The factor analysis was carried out by using the SPSS ® version 17 statistical program package. All 21648 land area samples and seven climate change exposure indicator variables were used in the factor analysis. Two variables (absolute change in annual number of summer days and relative change in annual number of days with snow cover) were excluded from the analysis because of the bimodal distribution.

Principal Component analysis was used to select the number of factors. In this phase, the variation of the seven selected climate change exposure indicator variables is divided to six Principal Components. Each of these components is assigned with an initial eigenvalue. If the eigenvalue of a component is higher than 1.0, the component will explain more of the total variation than any single original variable. It is common that the final number of produced factors is the number of principal components with eigenvalue higher than 1.0.

In the CCLM dataset three principal components had eigenvalue higher than 1.0. Thus it was designed to use three factors. Three principal components were able to explain 81% of the total variation.

Varimax-rotation was used to produce easily explainable factors. Rotated component matrix of the three Varimax-rotated factors is presented in Table 3. Factor scores for all three factors were assigned to each of the 21648 samples.

Table 3. Rotated component matrix of the three factors. Factors (components) 1 – 3 and loadings of the six variables.

Rotated Component Matrix[a]

	Component		
	1	2	3
Tmean change (A1B)	-.023	.917	.054
ln (Frost days change A1B+81)	.681	.011	.641
ln (Winter rain change A1B)	.765	.368	.042
Summer rain change % (A1B)	-.891	-.152	-.093
Heavy rainfall change (A1B)	-.450	-.667	-.033
ln (Surface runoff change A1B)	.003	.068	.974
Ln (Evaporation change A1B)	.903	-.009	.049

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Factor 1

The first factor had the highest loading of four variables: Relative change in mean annual evaporation, Relative change in annual mean precipitation in summer months, Relative change in annual mean precipitation in winter months, and Absolute change in annual number of frost days. High positive factor scores are assigned to areas where the evaporation will decrease, mean precipitation both in winter and summer months will decrease and the number of frost days is minimal. Negative factor scores indicate increasing evaporation, increasing rains in winter and in summer as well as decreasing number of frost days from present to the end of the predicted period 2071-2100.

The map shown in figure 29 is rather similar to the distribution of the change in annual number of summer days except for the British Isles.

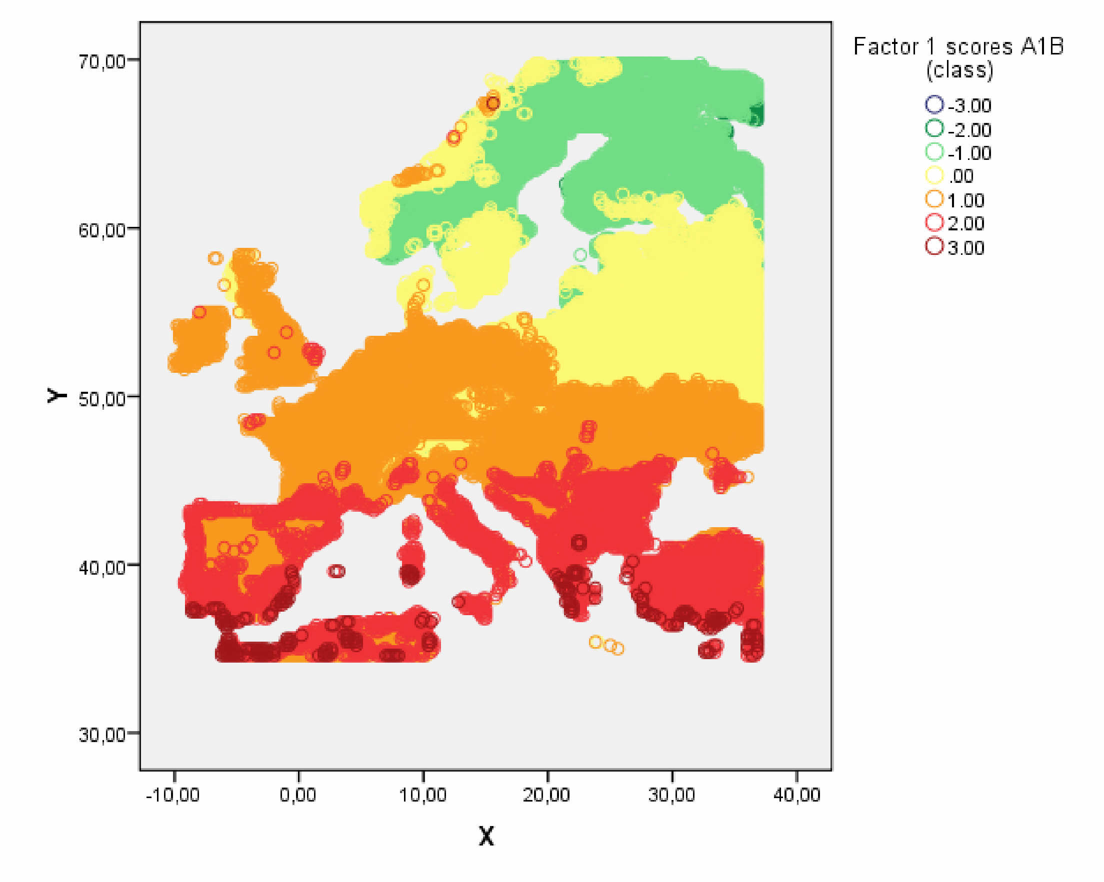

Fig. 29. Simplified map of factor scores for Factor 1 (scenario A1B).

Factor 2

The second factor had the highest loadings for absolute change in mean annual temperature and number of days with heavy rainfall. Positive factor scores indicate increasing temperature and decreasing number of days with heavy rainfall (Figure 30).

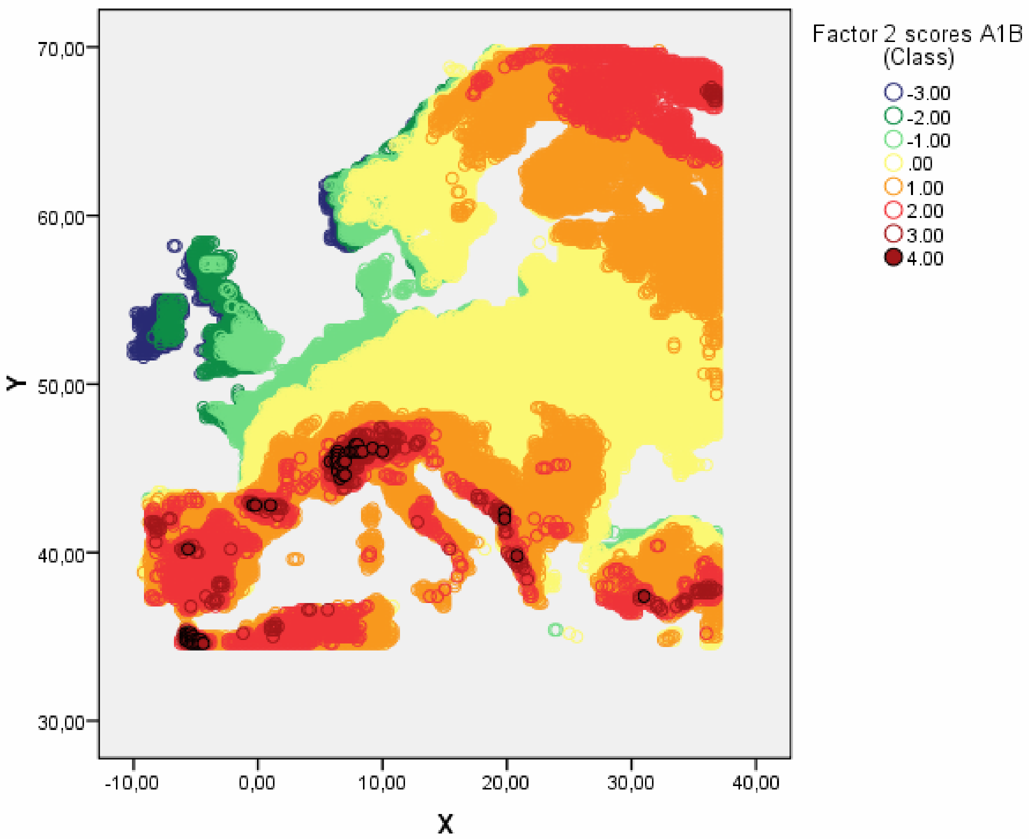

Fig. 30. Simplified map of factor scores for Factor 2 (scenario A1B).

Factor 3

The last factor had the highest loadings for relative change in mean annual surface runoff. Positive factor scores show increasing surface runoff (figure 31).

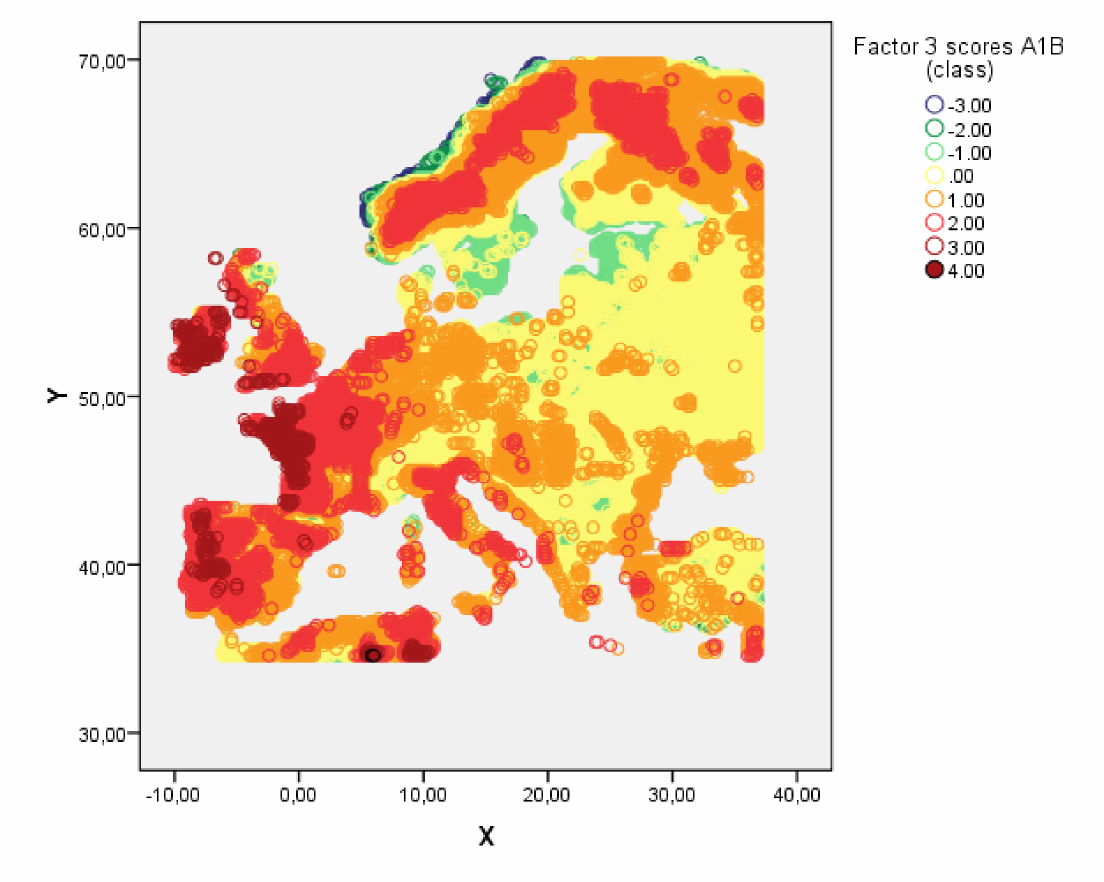

Fig. 31. Simplified map of factor scores for Factor 3 (scenario A1B).

B1 scenario

Factor analysis was applied in similar way to variables related to the scenario B1. Again in the CCLM dataset three principal components had eigenvalue higher than 1.0. Thus it was designed to use three factors. Three principal components were able to explain 80% of the total variation.

Varimax-rotation was used to produce easily explainable factors. Rotated component matrix of the three Varimax-rotated factors is presented in Table 4. Factor scores for all three factors were assigned to each of the 21648 samples.

Table 4. Rotated component matrix of the three factors. Factors (components) 1 – 3 and loadings of the six variables.

Rotated Component Matrix[a]

	Component		
	1	2	3
Tmean change (B1)	-.084	-.028	.927
ln (Frost days change B1 + 57)	.720	.603	-.025
ln (Winter rain change B1)	.648	.202	.401
Summer rain change (%) (B1)	-.925	-.041	.007
Heavy rainfall change (B1)	-.592	-.009	-.511
Surface runoff change % (B1)	.044	.971	.003
Ln (Evaporation change B1)	.897	.072	-.101

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factor 1

The first factor had the highest loading of five variables: Relative change in mean annual evaporation, Relative change in annual mean precipitation in summer months, Relative change in annual mean precipitation in winter months, Absolute change in annual number of frost days and number of days with heavy rainfall. High positive factor scores are assigned to areas where the evaporation will decrease, mean precipitation both in winter and summer months will decrease and the number of frost days is minimal. Also number of days with heavy rainfall will decrease. Negative factor scores indicate the opposite change from present to the end of the predicted period 2071-2100.

Map (Fig. 32) in close to the map of Factor 1 in the A1B scenario. The map shown in figure 32 is also rather similar to the distribution of the change in annual number of summer days except for the British Isles.

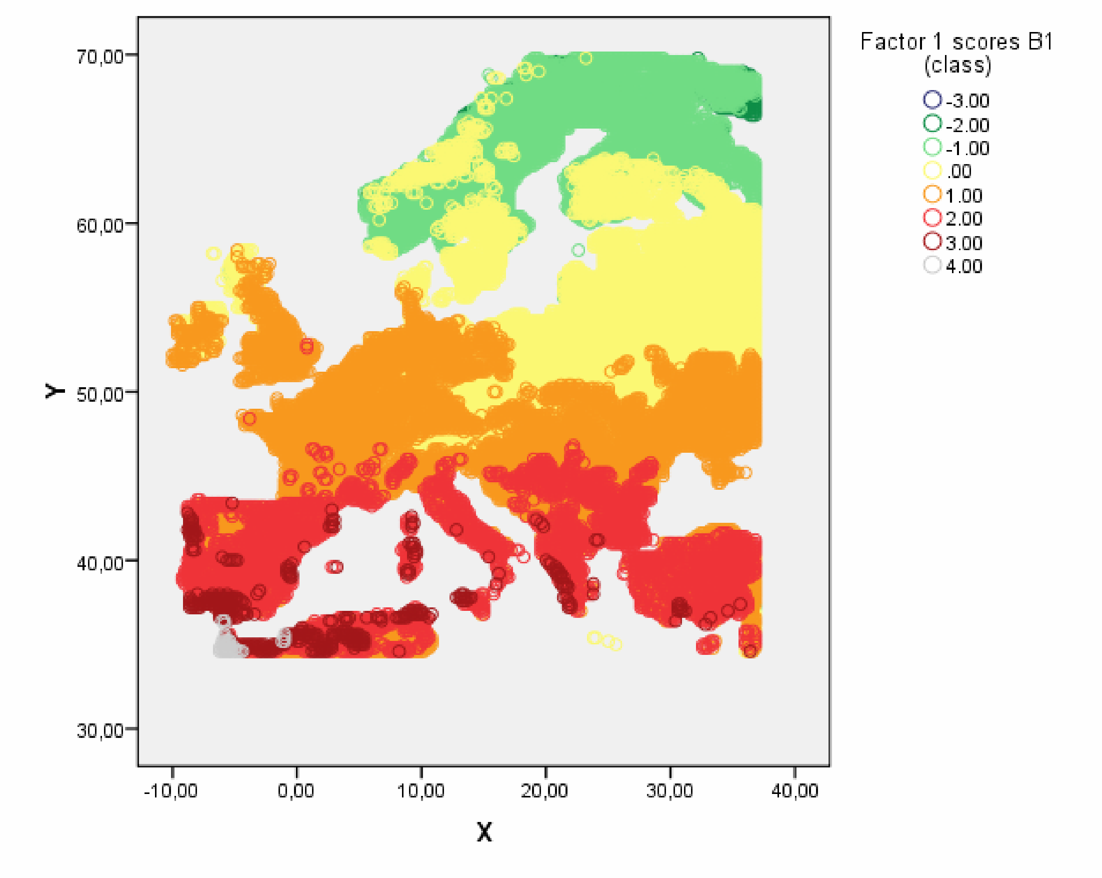

Fig. 32. Simplified map of factor scores for Factor 1 (scenario B1).

Factor 2

The second factor had the highest loadings for relative change in mean annual surface runoff. Positive factor scores show increasing surface runoff (figure 33). This factor is almost identical to the Factor 3 of the A1B scenario.

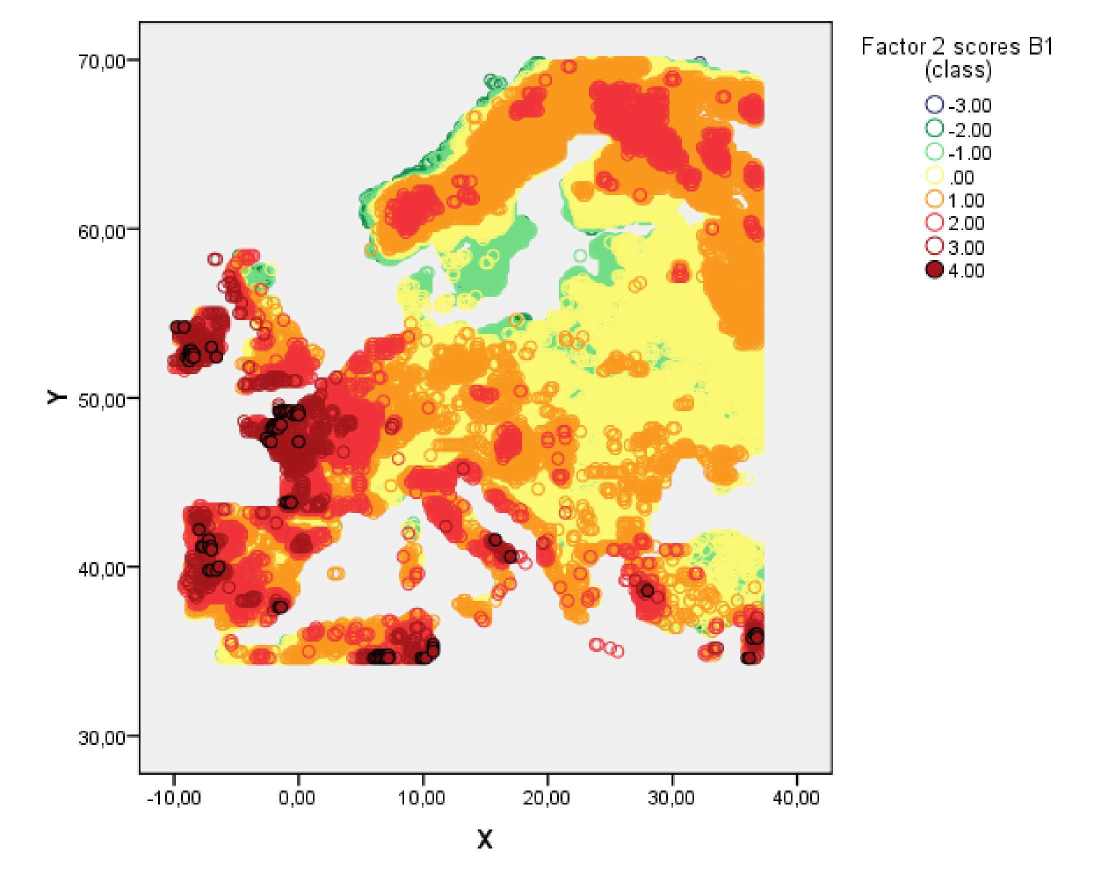

Fig. 33. Simplified map of factor scores for Factor 2 (scenario B1).

Factor 3

The last factor had the highest loadings for absolute change in mean annual temperature. Positive factor scores indicate increasing temperature (Figure 34).

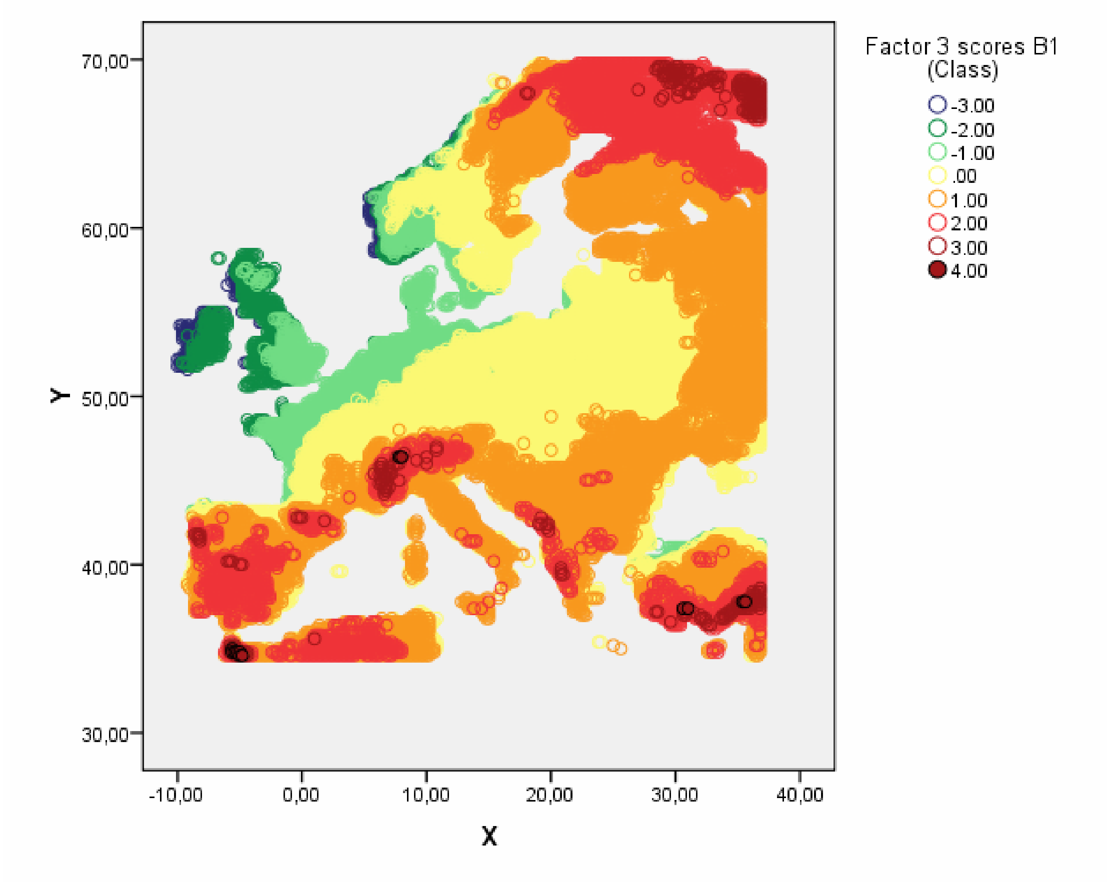

Fig. 34. Simplified map of factor scores for Factor 3 (scenario B1)

1.5 Conclusions

Factor analysis was tested as a method to reduce the complexity of the climate stimuli variables and time period from present to 2071-2100. Factor analysis is used to reduce the number of studied variables and to find few common factors behind the measured variables. These factors will be able to explain most of the variation in the whole dataset. All 21648 land area samples and seven climate change exposure indicator variables were used in the factor analysis. Two variables (absolute change in annual number of summer days and relative change in annual number of days with snow cover) were excluded from the analysis because of the bimodal distribution.

Principal Component analysis was used to select the number of factors. In the CCLM dataset three principal components had eigenvalue higher than 1.0. Thus it was designed to use three factors. Three principal components were able to explain 81% of the total variation.

Varimax-rotation was used to produce easily explainable factors. The first factor had the highest loading of four variables: Relative change in mean annual evaporation, Relative change in annual mean precipitation in summer months, Relative change in annual mean precipitation in winter months, and Absolute change in annual number of frost days. High positive factor scores are assigned to areas where the evaporation will decrease, mean precipitation both in winter and summer months will decrease and the change in frost days is minimal. Negative factor scores indicate increasing evaporation, increasing rain in winter and in summer as well as decreasing number of frost days from present to the end of the projected period 2071-2100.

The second factor had the highest loadings for absolute change in mean annual temperature and number of days with heavy rainfall. Positive factor scores indicate increasing temperature and decreasing number of days with heavy rainfall.

The last factor had the highest loadings for relative change in mean annual surface runoff and absolute change in annual number of frost days. Positive factor scores show increasing surface runoff and change in frost days is minimal.

The tested factor analysis showed that there are some climate change related trends that are common for most of the European regions. For example, decreasing evaporation and decreasing precipitation can be expected in large areas in Southern Europe. However, two important climate stimuli variables (absolute change in annual number of summer days and relative change in annual number of days with snow cover) showed bimodal distribution and the correlation coefficients between the studied variables were weaker than expected in the whole dataset.

In some European regions, the climate stimuli variables may change in different way compared to the general trends that can be found by factor analysis. While the objective of the project is to study effects of climate change to all European regions rather than find the most common development trends for Europe as a whole, it was decided that factor grouping will not be applied for the climate stimuli variables.

Tentative List of Indicators

Topic	Indicator	Data source	Spatial resolution
Climate change exposure			
Mean temperature	Change in annual mean temperature	CCLM	18x18 km raster cells
Frost days	Change of average annual number of frost days (with minimum temperatures below *0°C)*	CCLM	18x18 km raster cells
Summer days	Change of average annual number of summer days (days with maximum temperatures above *25°C*)	CCLM	18x18 km raster cells
Precipitation in winter months	Change of the average precipitation in kg/sqm in months December, January and February.	CCLM	18x18 km raster cells
Precipitation in summer months	Change of the average precipitation in kg/sqm in months June, July, August.	CCLM	18x18 km raster cells
Days with heavy rainfall	Change of the average annual number of days with heavy rainfall (above 20kg/sqm)	CCLM	18x18 km raster cells
Evaporation	Change of the average annual amount of water evaporating in a distinct area	CCLM	18x18 km raster cells
Days with snow coverage	Change of the average annual number of days with snow covering the surface of the reference area	CCLM	18x18 km raster cells
Physical sensitivity			
Settlements	X of settlement areas prone to heavy rainfall	CORINE	NUTS 3
	% of settlement area prone to sea level rise	CORINE	NUTS 3
Infrastructure	% of streets, rail networks, power plants prone to heavy rainfall	IRPUD, CORINE	NUTS 3
	% of streets, rail networks, power plants prone to sea level	IRPUD, CORINE	NUTS 3

	rise		
	km of streets and railways	IRPUD	NUTS 3
Environmental sensitivity			
Forests	Share of different types of forest on NUTS 3 area	CORINE	NUTS 3
Protected ecological areas	Share of Natura 2000 areas in relation to total NUTS 3 area	Natura 2000, EEA	NUTS 3
Ecologically valuable areas	Share of areas with high ecological value in relation to total NUTS 3 area	EEA, CORINE	NUTS 3
Sensitive ecological areas	Share of sensitive ecoregions in relation to total NUTS 3 area	EEA, ETC/NC	NUTS 3
	Percentage of fragmented natural areas	ESPON Hazards	NUTS 3
Erosion-endangered areas	Percentage of area with steep slopes and erosion endangered soils	CORINE	NUTS 3
Social sensitivity			
Total population	Absolute number of inhabitants in NUTS 3 area	EUROSTAT/ ESPON	NUTS 3
Urban population	% of population in settlements with more than 50,000 inhabitants	EUROSTAT/ ESPON	NUTS 3
Coastal population	% of population in coastal areas prone to sea level rise	CORINE / EUROSTAT	NUTS 3
Population endangered by river floods	% of population in areas prone to heavy rainfall	CORINE / EUROSTAT	NUTS 3
Senior citizens	Population share of inhabitants > 65 years	EUROSTAT	NUTS 3
Cultural sensitivity			
Cultural monuments	Density of monuments in NUTS 3 area	ESPON 2007	NUTS 3
	Density of monuments in areas prone to heavy rainfall	ESPON 2007, CORINE	NUTS 3
	Density of monuments in NUTS 3 area prone to sea level rise	ESPON 2007, CORINE	NUTS 3

	UNESCO world heritage areas prone to heavy rainfall	UNESCO, CORINE	NUTS 3
	UNESCO world heritage site in area prone to sea level rise	UNESCO, CORINE	NUTS 3
Cultural landscapes	Share of UNESCO cultural landscapes and conjuncts on total NUTS 3 area	UNESCO, CORINE	NUTS 3
Cultural institutions	Density of museums, galleries, theaters and public libraries areas prone to heavy rainfall	ESPON 2007, CORINE	NUTS 3
	Density of museums, galleries, theaters and public libraries in NUTS 3 area prone to sea level rise	ESPON 2007, CORINE	NUTS 3

For indicators on economic sensitivity and adaptive capacity see respective chapters in the main part of this report.

Data Availability Review for Balkan Countries and Turkey

This annex presents results of a first review on the availability of basic socio-economic data from Eurostat and national statistical offices in Balkan countries and Turkey. Identification of data sources and statistical data will continue in the coming months and exchange with other ESPON projects also covering these countries and similar data will intensify.

1. Albania

Availability of socio-economic data from the Albanian Institute of Statistics (INSTAT)

The Albanian Institute of Statistics (INSTAT) has not yet adopted the NUTS-classification system. But, with regard to the decision of the European Commission and the Albanian Research Committee from 2008, the following administrative units of Albania correspond to the NUTS classification system. The decision, with the given state of development of Albania, suggests defining the entire territory of Albania as the second NUTS level (convergence regions) for research purposes (website europa.org). Hence, the corresponding administrative units to the NUTS 3 level in Albania are its 12 counties. The EDORA interim report proves as well the non-existence of the NUTS classification system and supports the assimilation of counties to the NUTS three level (ESPON 2009, p.42).

CODE	Level 2 Entire territory	Level 3 Counties
	Albania	
		Berat
		Diber
		Durres
		Elbasan
		Fier
		Gjirokaster
		Korce
		Kukes
		Lezhe
		Shkoder
		Tirane
		Vlore

Table 1: Administrative units in Albania

The INSTAT website does not provide a spatial dataset of the administrative boundaries in Albania. Hence, the following figure shall illustrate the county boundaries equivalent to NUTS 3 level (see Figure 1). A spatial dataset covering more than these county boundaries will hopefully be available from ESPON/EUROSTAT.

Figure 1: *Spatial delineation of councils in Albania (Source: website Assembly of European Regions)*

At a first glance, the official website of the Albanian Institute of Statistics offers a large amount of data on social and economic indicators. But, most of the data is only available for the entire country (NUTS 2 equivalent level). Only two basic datasets (consumer spending and population data) display data from the councils and districts (NUTS 3 equivalent level or lower). The datasets are displayed and downloadable as MS Excel files. (website INSTAT)

Field	Dataset	Reference Year (latest)	Admin level
Population	Total population, population density, male and female population by districts	2008	4
Education	Children, Pupils and Students enrolled in the different education forms (kindergarten to university), students by speciality	2008	2
Living Conditions/ Dwellings	Distribution of households according to number of rooms, household durable stock, households and their mode of water and heating	2001	2
Wages	Wages and Salaries	2007	2
Employment	Unemployment, by sex and education Employment by economic activity, public sector	2007	2
Health	Various Indicators	2007	2
Consumer Spending	Household budgets by counties	2000	3
Tourism	Hotels and beds, overnights	2007	2
Economy	GDP per capita and various datasets	2007	2

Table 2: Basic socio-economic data from Instat potentially relevant to the project (Source: own illustration)

Availability of socio-economic data from Eurostat

The official website for Statistics of the European Commission (Eurostat) offers no data for the Republic of Albania. Although there are regional datasets for candidate and potential candidate countries for the European Union, data for the Republic of Albania is not yet available.
The next step is to discuss whether the data from INSTAT can be useful for the project concerning especially the spatial scale. The availability of many indicators only on national level limits the utility of data from INSTAT. Moreover, application of the data requires a discussion on probably different methodologies, definitions and coherence with other EU-wide datasets as for example available from Eurostat.

Altogether, data availability for Albania is constrained. The missing datasets for the regional level limits the application of the data from INSTAT for the project. As soon as the indicator catalogue has been worked out by the project team more decent and concrete reviews on data availability will have to be conducted.

Sources

ESPON, 2009. *EDORA Applied Research Project – Interim Report April 2009.* Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236 /2240/file_6622/edora_interim_report_version_300409.pdf [Accessed on 19/09/2009]

Website europa.org: Available at: http://cordis.europa.eu/documents/documentlibrary/102107161EN6.pdf [Accessed on 19/09/2009]

Website Instat: Available at: http://www.instat.gov.al/ [Accessed on 19/09/2009]

Website Assembly of European Regions: Available at: http://www.aer.eu/fileadmin/Images/ViCards/Region/Albania/albania_carte.gif [Accessed on 19/09/2009)

2. Bosnia-Herzegovina

Availability of socio-economic data from the Agency for Statistics of Bosnia and Herzegovina

In Bosnia and Herzegovina no NUTS classification exists. The administrative boundaries present cannot be combined with corresponding NUTS levels of EU member states because the population magnitudes of the units of the administrative levels are unequal (ESPON 2009, p.42). Moreover, the administrative structure of Bosnia and Herzegovina is in itself not homogenous. The entire territory is divided into two entities, the Federation of Bosnia and Herzegovina (F BiH) and the Republic of Srpska (RS). Besides these two entities, the Brčko District in the north-west is also self-administrative, although its size in area and population varies particularly from the two entities. The next administrative level of the entity Federation of Bosnia and Herzegovina is the level of ten cantons, which could be seen to be corresponding to regions at NUTS 3 level. In contrast to that, the second entity Republic of Srpska is missing this level of administration, being divided directly in a municipal structure of 62 municipalities. In the Federation of Bosnia and Herzegovina 79 municipalities on the municipal level exist below the Cantons. (Website Agency of Statistics A)

With regard to these disparities in administrative levels and dissimilarity to the NUTS classification, searching for an appropriate scale equivalent to other EU Member States in data collection and display becomes difficult. Giving an opportunity for an homogenous division of the country, the

Cross-border programme Bosnia and Herzegovina – Serbia of the European Union regards the economic regions as the third NUTS level (Commission of the European Communities 2008, p. 5).

A spatial dataset is not yet available to the project. The following illustration shall give an overview on the division of Bosnia and Herzegovina in entities and municipalities, also showing the special case of Brčko District.

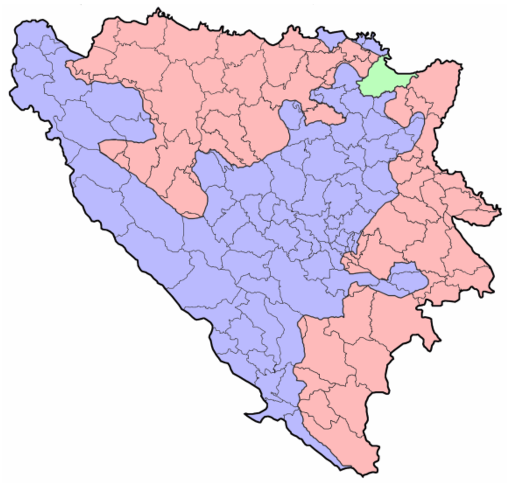

Figure 2: Spatial delineation of entities and municipalities in BiH (source: website Wikimedia)

The aforementioned variety in administrative division is also reflected in the data availability on the official website for statistics of the Republic of Bosnia and Herzegovina (Website Agency of Statistics B). Most of the data offered by the Agency of Statistics is only available for the entire country. Publications and surveys provide basic statistical data on population and economy in the form of pdf documents (Website Agency of Statistics C). No possibility of requesting an online database is existent. Moreover, regional data seems not to be available from this source. Only publications on data for the Brčko District reach a lower level of spatial units. But in fact, data gathering is additionally hampered by the construction status of the English version of the statistical website.

Availability of socio-economic data from Eurostat

There is no data available from Eurostat for Bosnia and Herzegovina.
To sum up one could say that even socio-economic data on a really basic level is not available for spatial units lower than the whole territory of Bosnia and Herzegovina at this point. In addition, the translation status of the website and publications hampers the data gathering in particular. With regard to the missing NUTS classification and notably constrained adoption of it and the low data availability from both, Eurostat and the Agency of Statistics, further data research should implicate contacting the relevant institutions.

Sources

Commission of the European Communities (2008): COMMISSION DECISION C(2008)3708 of 23/07/2008. Adopting the Cross–border programme Bosnia and Herzegovina – Serbia under the IPA-Cross–border Co–operation component, for the year 2008. [Online] Available at: http://ec.europa.eu/enlargement/pdf/bosnia_and_herzegovina/ipa/cbc_ipa_2008_bosnia_and_herzegovina_-_serbia_en.pdf [Accessed on 19/09/2009]

ESPON (2009): *EDORA Applied Research Project – Interim Report April 2009.* [Online] Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236/2240/file_6622/edora_interim_report_version_300409.pdf [Accessed on 19/09/2009]

Website Agency of Statistics A: Bosnia and Herzegovina. [Online] Available at: http://bhas.ba/eng/BiHStats.asp?Pripadnost=4&mode=dark [Accessed on 19/09/2009]

Website Agency of Statistics B: Agency for Statistics of Bosnia and Herzegovina. [Online] Available at: http://bhas.ba/eng/default.asp?Pripadnost=1&mode=dark [Accessed on 19/09/2009]

Website Agency of Statistics C: Publications. [Online] Available at: http://bhas.ba/eng/Pub.asp?Pripadnost=6&mode=dark [Accessed on 19/09/2009]

Website Wikimedia: [Online] Available at: http://upload.wikimedia.org/wikipedia/commons/f/f8/BH_municipality_location.gif [Accessed 19/09/2009]

3. Croatia

Availability of socio-economic data from CROSTAT

According to the EDORA Applied Research Project Interim Report (ESPON 2009, p. 42), the NUTS classification has already been adopted in Croatia. The relevant spatial units to the project are its 21 counties, which are according to Eurostat representing the NUTS 3 level in Croatia (Eurostat 2008, p. 30). The next higher levels of the NUTS classification are 3 regions at NUTS level 2 and the entire territory of Croatia at NUTS level 1 (see Table 3).

Code	**Level 1**	**Level 2**	**Level 3**
HR0	HRVATSKA		
HR01		Sjeverozapadna Hrvatska	
HR011			*Grad Zagreb*
HR012			*Zagrebačka županija*
HR013			*Krapinsko-zagorska županija*
HR014			*Varaždinska županija*
HR015			*Koprivničko-križevačka županija*
HR016			*Međimurska županija*
HR02		Središnja i Istočna (Panonska) Hrvatska	
HR021			*Bjelovarsko-bilogorska županija*
HR022			*Virovitičko-podravska županija*
HR023			*Požeško-slavonska županija*
HR024			*Brodsko-posavska županija*
HR025			*Osječko-baranjska županija*
HR026			*Vukovarsko-srijemska županija*
HR027			*Karlovačka županija*
HR028			*Sisačko-moslavačka županija*
HR03		Jadranska Hrvatska	
HR031			*Primorsko-goranska županija*
HR032			*Ličko-senjska županija*
HR033			*Zadarska županija*
HR034			*Šibensko-kninska županija*
HR035			*Splitsko-dalmatinska županija*
HR036			*Istarska županija*
HR037			*Dubrovačko-neretvanska županija*

Table 3: *Administrative units in the Republic of Croatia (Source: Eurostat 2008)*

A spatial dataset covering these statistical regions may be available from Eurostat, because the publication "Statistical regions for the EFTA countries and the Candidate countries 2008" contains a map showing the 3 levels of statistical regions of Croatia (see Figure 3, Eurostat 2008, p. 32). CROSTAT does not provide a spatial dataset.

Figure 3: Statistical Regions of Croatia (Source: Eurostat 2008, p. 32)

A first look at the data from the Central Bureau of Statistics of Croatia (CROSTAT) reveals that statistical data for different spatial levels is generally available. But, also according to the EDORA Applied Research Project Interim Report, the data offered by CROSTAT is limited in terms of data format. Besides the Agricultural Census 2003, which provides the data in the CROSTAT database (PC AXIS application with the possibility to put out data tables), data is only available in publications in pdf or html format. Providing the relevant data for the councils of Croatia, the statistical yearbooks of CROSTAT cover the reference years from 2003 to 2008. For instance, the statistical yearbook 2008 comprises a statistical review by councils covering different socio-economic indicators. The indicators are similar to the ones used by the rest of the candidate countries and deal for example with population, business entities, employment, tourism, environment and education (Website CROSTAT). The website also provides population data created during the last census in 2001. This data is available in html tables.

Availability of socio-economic data from EUROSTAT

Data for Croatia is generally available from EUROSTAT, but is limited to the NUTS level 2. Moreover, the only dataset available is the unemployment rate for males and females with the most recent reference year of 2007 (Website EUROSTAT).

Overall, data availability for the Republic of Croatia is constrained. The data situation is comparable to the one of Serbia. Data taken from publications is limiting the usefulness of the data for the project, because it has to be reprocessed. Although Croatia has adopted the NUTS classification system, the databases provided by CROSTAT do not offer an adequate range of data yet. As mentioned already for Serbia, data may be obtainable directly by contacting EUROSTAT as well as CROSTAT.

Sources

ESPON (2009): EDORA Applied Research Project – Interim Report April 2009. [Online] Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236/2240/file_6622/edora_interim_report_version_300409.pdf [Accessed on 19/09/2009]

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4. Kosovo

Availability of socio-economic data from the Statistical Office of Kosovo

The ESPON FOCI inception report (ESPON 2008, p. 8) proposes the seven districts of Kosovo to be used as NUTS 3 units, because the NUTS classification has not yet been adopted for the Kosovo. But, it is also indicated that the assimilation of these districts to NUTS 3 cannot happen without difficulties. However, the main administrative level in the Kosovo is the municipal one with the 33 municipalities shown in the map below (see Figure 4, website Statistical Office A).

With regard to the districts, there is no spatial dataset available to the project at this point. The district level seems not to be relevant to the Statistical Office, because data is only available for the national level (website Statistical Office B).

Figure 4: Overview of Kosovo and its Municipalities (Source: Website Statistical Office A)

After examining the availability of socio-economic data from the Kosovo, it has to be said that the website of the Statistical Office provides only basic socio-economic data for the national level. NUTS 3 equivalent data is not obtainable from this source. The data availability of the Kosovo was also seen to be limited by the EDORA Interim Report (ESPON 2009, p. 42), which stated that basic socio-economic data is publicly available, but only in terms of html and/or pdf documents such as publications.

Availability of socio-economic data from EUROSTAT

There is no socio-economic data available from EUROSTAT for the Republic of Kosovo.

Overall, the data availability for the Republic of Kosovo is constrained in particular. Although the districts could be assimilated to NUTS 3 level, there is not data for statistical units lower than the national level existent. Furthermore, the available data for the national level is not presented in a database but in html and/or pdf documents, which reduces the usefulness of the data for the project even more.

Sources

ESPON (2008): FOCI Future Orientations for Cities, Applied Research Project. Inception Report. [Online] Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236/2239/file_5608/foci_inception_report3.pdf [Accessed 19/09/2009]

Website Statistical Office A: Kosovo's territorial-municipal structure. [Online] Available at: http://www.ks-gov.net/ESK/eng/index.php?option=com_content&view=article&id=37&Itemid=27 [Accessed 19/09/2009]

Website Statistical Office B: Statistical Office of Kosovo. [Online] Available at: http://www.ks-gov.net/ESK/eng/index.php?option=com_content&view=frontpage&Itemid=1 [Accessed 19/09/2009]

5. Montenegro

Availability of socio-economic data from the Statistical Office of Montenegro

Montenegro has not yet adopted the NUTS classification for its statistical regions. The country's most important administrative levels are the national and the municipal level. The municipalities are the basic unit of self-government in Montenegro (IPA CBC 2007, p. 1). Hence and according to the EDORA Applied Research Project Interim Report (ESPON 2009), the whole country "could be assimilated to NUTS 1, NUTS 2 and NUTS 3" (ESPON 2009, p. 42).

A spatial dataset of Montenegro is not yet available to the project. The following figure shall give a first impression of the spatial extension of Montenegro and its surrounding countries (see Figure 5).

Figure 5: Overview of Montenegro (Source: Website Ilo)

Data availability of the Republic of Montenegro was also examined by the EDORA Interim Report (ESPON 2009). It states that basic socio-economic data is publicly available from the website of the Statistical Office (MONSTAT, Website MONSTAT A). Because the entire territory of Montenegro is assimilated to NUTS 1 to NUTS 3, given national data of Montenegro covers already the relevant data scale. With regard to Serbia and Croatia, the data provision concerning the data format is similar. No databases exist for statistical data on the website of MONSTAT. The socio-economic data is only available via the list of publications appearing in html and/or pdf documents. Nevertheless, various data tables are provided by MONSTAT through publications. For instance, the statistical yearbook 2008 comprises population data (Census 2003), data on education and social welfare. The data on the economy covers for example employment, GDP, construction, trade, tourism and transport (Website MONSTAT B). The section of Annual data offers the possibility to view the data for Montenegro in html tables online.

Availability of socio-economic data from EUROSTAT

There is no socio-economic data available from EUROSTAT for the Republic of Montenegro.

Summarising, for Montenegro the project has to deal with the same problems in data availability as for Serbia and Croatia. No online databases are available and data can only be extracted from pdf and/or html documents. However, data seems to be complete and indicators are corresponding to the other candidate countries. Still it has to be discussed whether the definitions of indicators and the year of reference are comparable to datasets of the Member States of the EU as well as the data is reliable.

Sources

ESPON (2009): EDORA Applied Research Project – Interim Report April 2009. [Online] Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236/2240/file_6622/edora_interim_report_version_300409.pdf [Accessed on 19/09/2009]

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6. Macedonia

Availability of socio-economic data from the State Statistical Office of Former Yugoslav Republic of Macedonia (FYROM)

The Former Yugoslav Republic of Macedonia has already adopted the NUTS classification for its spatial delineations (ESPON 2009, p. 42). The administrative units relevant to the project are the regions of the FYROM, as they are determined as NUTS 3 equivalent according to Eurostat (Eurostat 2008, p. 34). Accordingly, available data should be organised in an appropriate structure and scale to use it for the project. Both, the first and second NUTS equivalent levels, are seen to be the level of the entire territory of the FYROM (see Table 4). Subsequently, the third level corresponding to NUTS 3 is the regional level with the eight regions of the FYROM. With regard to Table 4, it has to be said that the country code MK is provisional and does not represent the definitive nomenclature for the FYROM in future (Eurostat 2008, p. 34).

Code	**Level 1**	**Level 2**	**Level 3**
MK			
MK0	PORANEŠNATA JUGOSLOVENSKA REPUBLIKA MAKEDONIJA		
MK00		Poranešnata jugoslovenska Republika Makedonija	
MK001			*Vardarski*
MK002			*Istočen*
MK003			*Jugozapaden*
MK004			*Jugoistočen*
MK005			*Pelagoniski*
MK006			*Pološki*
MK007			*Severoistočen*
MK008			*Skopski*

Table 4: Administrative units in the Former Yugoslav Republic of Macedonia (Source: Eurostat 2008)

The website of the State Statistical Office of the FYROM does not offer a spatial dataset of these levels of administration. The following figure shall give a first impression of the regions, their area and their distribution across the FYROM (see Figure 6). A spatial dataset may be available from ESPON/Eurostat.

Figure 6: Regions of the Former Yugoslav Republic of Macedonia (Source: *website wikimedia*)

The EDORA interim report (ESPON 2009) states that "data accessibility for FYROM is more limited than in the rest of the Western Balkan countries". The official website of statistics in the FYROM, the website of the State Statistical Office (website State Statistical Office), provides an online database of statistical data and publications of the institute. The database offers a population census of 2002, a foreign trade database and a database of regional statistics. Publications like the Statistical Yearbook (e.g. "Regions of the Republic of Macedonia, 2007". Available at: http://www.stat.gov.mk/Publikacii/ GodisnikRegioni2007.pdf) are only available in downloadable form (pdf documents) and cannot be accessed online. But, the regional statistics database as well as the "Regions of the Republic of Macedonia 2007" publication represent sources of data even for the NUTS 3 level.

The regional statistics database offers data on the following areas, which can be requested by an online application (PC-AXIS):

Field	Dataset	Reference Year (latest)	Admin level
Agriculture, Environment	Animal production (number), crop production (amount), Environment (amount of waste)	2008	3
Business Entities	Number of active business entities	2008	3
Education	Students in different school forms, levels of education, pupils and children enrolled	2008	3
Internal Trade	Retail trade	2008	3
Industry, Construction and Energy	Number of buildings, industrial production, energy consumption	2008	
Labour Market	Activity rates of population	2008	3
National Accounts	GDP per capita, Gross value	2007	3
Population	Basic demographic indicators, estimations, migrations	2008	3
Social Statistics	Social cash benefit	2008	3
Tourism/Transport	Carried passengers, data on hotels and overnights, capacities, registered passenger cars, road network	2008	3

Table 5: Basic socio-economic data from the State Statistical Office of the FYROM potentially relevant to the project (Source: own illustration)

Availability of socio-economic data from Eurostat
For the Former Yugoslav Republic of Macedonia only one dataset is available from Eurostat. Moreover, the Gross Domestic Product per capita 2006 dataset is only covering the first or second NUTS level of the FYROM, meaning the entire territory of the country (Website EUROSTAT).

Overall, the datasets and publications of the State Statistical Office of the Republic of Macedonia present basic socio-economic data on the NUTS 3 equivalent regions in Macedonia, although publication data cannot easily be reprocessed to be used for further analysis. The data requested through the PC-AXIS online application can be put out in various file formats such as *.dbf and *.xls, which enables the project to directly work with the datasets. Furthermore, the amount of indicators and request opportunities shows an enhancing availability of socio-economic data compared to the statement of the EDORA interim report, that data availability is more limited than in the rest of the Western Balkan Countries (see above). But, it has to be discussed whether this data can be useful for the project concerning time reference, definitions and coherence with other EU-wide datasets as for example available from Eurostat. As soon as the indicator catalogue has been worked out by the project team more decent and concrete reviews on data availability will have to be conducted.

Sources

ESPON (2009): EDORA Applied Research Project – Interim Report April 2009. [Online] Available at: http://www.espon.eu/mmp/online/website/content/programme/1455/2233/2236/2240/file_6622/edora_interim_report_version_300409.pdf [Accessed on 19/09/2009]

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7. Serbia

Availability of socio-economic data from the Statistical Office of the Republic of Serbia

In the Republic of Serbia no NUTS classification of spatial units exists. But in fact, the administrative units of Serbia could be adapted to NUTS levels (ESPON 2009, p. 42). According to the European Cross-border Cooperation Programme between Bulgaria and Serbia, the districts of Serbia as the main administrative unit can be regarded as NUTS 3 level (Website City of Nis).
With regard to this administrative structure, the 29 districts of Serbia representing the third NUTS level are the following (Website Arhiva):

Borski, Branicevski, Jablanicki, Backa South, South Banat, Kolubarski, Kosovski, Kosovsko-Mitrovacki, Kosovsko-Pomoravski, Macvanski, Moravicki, Nisavski, Pcinjski, Pecki, Pirotski, Podunavski, Pomoravski, Prizrenski, Rasinski, Raski, Backa North, North Banat, Banat Central, Sremski, Sumadijski, Toplicki, Zajecarski, Backa West and Zlatiborski

A spatial dataset is not yet available to the project, because it is not provided by the website of the Statistical Office. For a first overview over the NUTS three level units of Serbia the following image can be used (see Figure 7). Eurostat or ESPON may hold a spatial dataset to which the available data can be linked later on.

Figure 7: Districts in the Republic of Serbia (Source: *Website City of Nis*)

At a first glance the website of the Statistical Office of Serbia holds national and regional socio-economic data, which is publicly accessible. On one hand statistical publications such as yearbooks up to the year of reference 2008 are available in downloadable form (pdf-documents).

The documents present data on national as well as on regional/municipal level, e.g. in the Municipality Yearbooks (available for the years 2004-2008, Website Statistical Office A). On the other hand and of more importance to the project, different databases can be accessed online and special datasets can be requested. The database offering data for the NUTS 3 level is the one “Municipalities in Figures” (Website Statistical Office B). 44 municipal indicators on economics, population, infrastructure, education and social issues can be requested from the database for both, municipalities and the districts as the next higher administrative level. The following table (see Table 6) illustrates data and indicators available to request from the database. At first appearance, the data for the districts seems to be complete.

Field	Dataset	Reference Year (latest)	Admin level
Demography	Total population by districts and municipalities	2002	3
Education	Children, Pupils and Students enrolled in the different education forms, number of schools and institutes	2007	3
Living Conditions/ Dwellings	Completed dwellings per 1000 inhabitants	2007	3
Wages	Net Wages	2007	3
Employment	Independent employees, employees in enterprises, employees per 1000 inhabitants, share of females	2007	3
Tourism	Tourist nights	2007	3
Economy	Wages, Employees in Enterprises	2007	3

Table 6: Basic socio-economic data from the Statistical Office of the Republic of Serbia potentially relevant to the project (Source: Website Statistical Office B)

Availability of socio-economic data from Eurostat
There is no data available from Eurostat for the Republic of Serbia.

Overall, it has to be said that data availability from the Statistical Office of Serbia is limited, although data in terms of tables is existent. The statistical yearbooks are not an appropriate source for the project, because for further computation and analysis a time-consuming reprocessing of the data is needed. Nevertheless, the database “Municipalities in Figures” provides basic data on social issues and economy in the districts and municipalities which can be requested via choice of area and indicator. Limiting the use of the database for the project, the data requested for an area is put out in an html document. Instead of being able to request data tables showing the data of one indicator for all areas, it is only possible to request several indicators for one spatial unit and not conversely. Moreover, as the last population census has taken place in 2002, the use of the demographic data seems also to be limited. Ten of the indicators stem from the data of 2002.
Evaluating the data availability for Serbia, it seems that basic data is available from the Statistical Office. In terms of its usefulness to the project, the data has to be reprocessed for the use in the project’s work. It may be possible to request data tables in an appropriate format from the Statistical Office itself. Usefulness and appropriateness of the data in terms of time reference, definitions and coherence with other datasets has to be appraised after a discussion of the actual indicator catalogue for the project. Thereupon, more decent reviews on data availability will have to be conducted.

Sources

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Website Statistical Office A: Municipalities of Serbia. [Online] Available at: http://webrzs.statserb.sr.gov.yu/axd/en/ops.htm [Accessed on 19/09/2009]

Website Statistical Office B: Municipalities of Serbia. [Online] Available at: http://webrzs.statserb.sr.gov.yu/axd/en/pok.php?god=2008 [Accessed on 19/09/2009]

8. Turkey

Availability of socio-economic data from Turkstat

As already stated in the inception report, Turkey has already adopted the NUTS-classification system. Accordingly, geographic delineations of administrative levels should be available in a consistent system. According to Turkstat, the Turkish Statistical Institute NUTS 1 level equivalents in Turkey are called regions while NUTS 2 level equivalents are denoted to be subregions and on the NUTS 3 equivalent level provinces are delineated (see Table 7).

CODE	Level 1 Regions	Level 2 Subregions	Level 3 Provinces	CODE	Level 1 Regions	Level 2 Subregions	Level 3 Provinces
TR1	İstanbul			TR72	Middle Anatolia	Kayseri	
TR10		İstanbul		TR721			Kayseri
TR100			İstanbul	TR722			Sivas
TR2	Western Marmara			TR723			Yozgat
TR21		Tekirdağ		TR8	Western Mediterranean		
TR211			Tekirdağ	TR81		Zonguldak	
TR212			Edirne	TR811			Zonguldak
TR213			Kırklareli	TR812			Karabük
TR22		Balıkesir		TR813			Bartın
TR221			Balıkesir	TR82		Kastamonu	
TR222			Çanakkale	TR821			Kastamonu
TR3	Aegean			TR822			Çankırı
TR31		İzmir		TR823			Sinop
TR310			İzmir	TR83		Samsun	
TR32		Aydın		TR831			Samsun
TR321			Aydın	TR832			Tokat
TR322			Denizli	TR833			Çorum
TR323			Muğla	TR834			Amasya

TR33		Manisa		TR9	Eastern Blacksea		
TR331			Manisa	TR90		Trabzon	
TR332			Afyon	TR901			Trabzon
TR333			Kütahya	TR902			Ordu
TR334			Uşak	TR903			Giresun
TR4	Eastern Marmara			TR904			Rize
TR41		Bursa		TR905			Artvin
TR411			Bursa	TR906			Gümüşhane
TR412			Eskişehir	TRA	North Eastern Anatolia		
TR413			Bilecik	TRA1		Erzurum	
TR42		Kocaeli		TRA11			Erzurum
TR421			Kocaeli	TRA12			Erzincan
TR422			Sakarya	TRA13			Bayburt
TR423			Düzce	TRA2		Ağrı	
TR424			Bolu	TRA21			Ağrı
TR425			Yalova	TRA22			Kars
TR5	Western Anatolia			TRA23			Iğdır
TR51		Ankara		TRA24			Ardahan
TR510			Ankara	TRB	Middle Eastern Anatolia		
TR52		Konya		TRB1		Malatya	
TR521			Konya	TRB11			Malatya
TR522			Karaman	TRB12			Elazığ
TR6	Mediterranean			TRB13			Bingöl
TR61		Antalya		TRB14			Tunceli
TR611			Antalya	TRB2		Van	
TR612			Isparta	TRB21			Van
TR613			Burdur	TRB22			Muş
TR62		Adana		TRB23			Bitlis
TR621			Adana	TRB24			Hakkari
TR622			Mersin	TRC	Southeastern Anatolia		
TR63		Hatay		TRC1		Gaziantep	
TR631			Hatay	TRC11			Gaziantep
TR632			Kahramanmaraş	TRC12			Adıyaman
TR633			Osmaniye	TRC13			Kilis
TR7	Middle Anatolia			TRC2		Şanlıurfa	
TR71		Kırıkkale		TRC21			Şanlıurfa
TR711			Kırıkkale	TRC22			Diyarbakır
TR712			Aksaray	TRC3		Mardin	
TR713			Niğde	TRC31			Mardin
TR714			Nevşehir	TRC32			Batman

TR715	Kırşehir	TRC33	Şırnak
		TRC34	Siirt

Table 7: Administrative units in Turkey (Source: Website Turkstat)

A spatial dataset covering these administrative boundaries is not yet available to the project but may be available from ESPON and/or EUROSTAT. However, to illustrate the spatial delineation of administrative units in Turkey the following map may be useful (see Figure 8).

Figure 8: Spatial delineation of administrative units in Turkey (Source: *Aydinoglu, Azendi, Aomralioglu, 2007*)

A first and preliminary inventory of potentially relevant data available from Turkstat reveals that at least some very basic datasets exist even at NUTS 3-equivalent level. Time references vary from 2001 to 2008 considering the most recent revisions available for each dataset (see Table 8) and at a first glance the very basic datasets seem to be rather complete.

Field	**Dataset**	**Reference Year (latest)**	**Admin level**
Demography	Total population	2000	3
Education	Total population by, literacy and education level	2000	3
Buildings	Number of Buildings	2007	3
Tourism	Number of Nights/beds/arrivals	2007	3
Health	Number of hospitals/Health personnel	2007	3
Employment	Employment by economic activity	2008	2
Business	Number of enterprises	2007	3
Economy	GDP per capita	2001	3

Table 8: Basic socio-economic data from Turkstat potentially relevant to the project (Source: own illustration)

Availability of socio-economic data from Eurostat

Field	**Dataset**	**Reference Year (latest)**	**Admin level**
Economy	GDP per capita	2001	2
Employment	Rate of unemployment (overall, male, female)	2006	2

Table 9: Basic socio-economic data from Eurostat potentially relevant to the project (Source: own illustration)

The official website for Statistics of the European Commission (EUROSTAT) offers just two datasets on subregions (NUTS level 2) in Turkey. These datasets seem not be useful with regard to their reference year and their administrative level.

Still it has to be discussed whether these datasets can be useful for the project concerning time reference, definitions and coherence with other EU-wide datasets as for example available from Eurostat. Overall this imposes the appraisal that data availability is constrained for Turkey at with respect to freely available data from the Turkish Statistical Institute Turkstat. As soon as the indicator catalogue has been worked out by the project team more decent and concrete reviews on data availability will have to be conducted.

Sources

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Website Turkstat: Regional statistics. [Online] Available at: http://tuikapp.tuik.gov.tr/Bolgesel/menuAction.do?dil=en [accessed on 07/08/2009]

Review of Mitigation and Adaptation Policy in the ESPON Space

1. Introduction

Climate change is unequivocal (IPCC 2007) and there is a need for the global society to respond to the unprecedented challenges in the coming decades. Societies can respond by mitigating their emissions of green house gases, thus slowing down the speed and scale of changes. Simultaneously, societies need to take into account the fact that warming has already been loaded into the global climate system that will inevitably lead to impacts that will be felt globally. Thus, societies need to adapt to changes in climate by formulating policies that enable adaptation to take place and by putting into place measures that build capacity to respond to the changes.

Europe plays an important role in global climate policy that aim to reach a global deal for emissions reductions and encourage adaptation. The EU position on climate change mitigation was outlined in the Climate action and renewable energy package (Commission of the European Communities 2008). With the negotiations for the Conference of Parties 15 underway, the European Union has stated that its aims for emissions reductions are a 20 percent reduction of green house gases by 2020. The second target of the Union is to increase the share of renewable energies to 20 percent in energy consumption by 2020. Adaptation, on the other hand, was initially considered a predominantly developing country issue due to their lower capacity and resources to adapt to changes. However, in the past five years adaptation has also become a policy goal in many European countries with majority of the European countries now having started or completed their national adaptation strategies (NAS). The EU, following national developments, published a white paper in 2009 that outlines the Union's approach to adaptation. It outlines the Union's approach to adaptation, which in the next two years focuses on accumulating knowledge and sharing that through a clearing house mechanism (Commission of the European Communities 2007).

This report reviews both mitigation and adaptation policies within the ESPON space, contributing to the work package 2.4 of the ESPON Climate programme. The aim of the report is to review existing policies on mitigation and adaptation in order to address the institutional and governance dimensions of territorial potentials of the NUTS3 regions. Firstly, the report discusses briefly the governance context of mitigation and adaptation, highlighting the multi-level nature of decision-making inherent in both. Secondly, this report reviews the aims of the EU mitigation policy and targets for reducing carbon emissions within the Union. There are also several EU directives and commitments that directly affect regions which will be reviewed. Thirdly, adaptation policy within the European context is addressed, showing how countries have had more chance ability to pursue their own policy agenda. This report reviews studies focusing on the national as well as on the regional level adaptation initiatives. The report concludes by highlighting the need to acknowledge that mitigation and adaptation take place within multilevel governance systems.

2. Governance of European regions

There is a growing recognition that the government no longer is a single source of authority when it comes to decision-making in societies but that governance of societies is now more complex and this is also holds true for mitigation and adaptation. Increasingly, actors outside the sphere of the state take part in decision-making, leading to the rise of partnerships between the state and civil society in the form of partnerships and networks (Bulkeley, Betsill 2003). Furthermore, the role of the state has changed from controlling and commanding to steering and enabling in the process of governance. Decision-making processes across multiple levels can naturally take place vertically but also horizontally across multiple sectors of administration. Governance, a terms mainly used in political science, has been defined as a system of continuous negotiation among nested governments at several territorial tiers- supranational, national, regional and local (quoted in (Hooghe, Marks 2003). This definition of governance, unsurprisingly, arises from the European context and is particularly relevant in the context of the European regions.

ESPON 2.3.2 Governance project focused on the governance of regions in Europe and considered the issue of multiple scales as one of the most important (Farinos Dasi et al. 2006). It is acknowledged that regional models of governance are to a large extent depended on the vertical organisation of the each country. Inherent in the structures of each country are the relationships between the different governmental levels and other stakeholders. In addition, the ESPON governance project also concludes that the vertical dimensions of governance are much more evolved than those of related to the horizontal dimension. This is particularly interesting, considering that sectoral co-operation and policy integration across sectors is regarded as one of the most pressing challenges of both successful mitigation and adaptation (Mickwitz et al. 2009).

In addition to taking into account the governance system of a country, it is important to note that the traditions of environmental policy-making and planning cultures play significant roles in both mitigation and particularly in designing adaptation measures (Keskitalo 2010). Newton and Thornley have identified families of legal and administrative systems in Europe, dividing the systems according to the ways in which balance between central and local power is distributed (Leary 1999). This division into different traditions is based on legal and administrative structures that affect how the countries are governed, and the authors identify five families within Europe, see Table 1. The term legal refers to the historical developments of the legal system and its legal sources and ideology, whereas administrative systems are considered to be the administration of local government and local democracy.

Table 1 Legal and administrative families in Europe.

Family	Legal families	Administrative families
British	England, Wales, Ireland	UK, Ireland
Scandinavian	Norway, Sweden, Denmark, Finland	Norway, Sweden, Denmark, Finland
Germanic	Germany, Switzerland, Austria (Eastern Europe), Greece	Germany, Switzerland, Austria (Spain, Belgium)
Napoleonic	France, Italy, Spain, Portugal, Belgium, Luxembourg, Netherlands, (Greece)	France, Italy, Spain, Portugal, Belgium, Luxembourg, Netherlands, Greece, (Spain, Belgium)

Although these divisions affect the way in mitigation and adaptation are governed, it does not necessarily mean that they alone determine the shape that climate change policies take in these countries. Even though these differences in legal and administrative traditions are not further discussed in this report, it is necessary to keep in mind that there are several European traditions of decision-making that underlie the implementation of climate change measures within the Union.

3. Methodology

The aim of this report is to review mitigation and adaptation policy in the ESPON space. It is acknowledged that in terms of both adaptation and mitigation, European regions are greatly affected by policies arising not only from the national level but also from the European Union and from the international fora. In addition to this, sub-national actors across Europe themselves are now pursuing their own strategies in order to adapt and mitigate climate change. In order to cover both, this report analyses all three levels of governance, the European, national and the regional. It is also acknowledged that the local level can be an important level of governance in some European countries, even more so than the regional level but this level is not explicitly addressed in this report. Although extending the analysis across several levels of governance does to certain extent move the emphasis away from the regional level, it nevertheless gives a more accurate picture of the governance environment within which the regions operate.

The aims of this review are accomplished by using secondary sources, and this is mainly due to constraints placed on time and resources. In terms of the EU level, policy documents are the main source of information for both mitigation and adaptation policies. In terms of national mitigation policy, main sources of data were research reports and reviews that have analysed the use of mitigation policy instruments across the Member States, as well as published studies on mitigation policy in Europe. In terms of regional mitigation strategies, studies of regional measures were used as well as policy documents from the EU level.

In terms of adaptation policy, national adaptation strategies (NAS) and analyses of them were used for those countries where one existed. There are a number of Union wide studies of comparative NAS development which were used. Secondly, important sources of data were case studies of regional climate strategies and regional adaptation strategies (RAS), although these are very few and present a problem in terms of coverage of the European regions. However, they present a valuable source of information on a rapidly moving policy field, and can be used to get an indication of what is happening on adaptation at the regional level in Europe. Furthermore, it should be acknowledged that in many cases at the regional level both adaptation and mitigation are considered in a joint climate strategy that addresses both concerns. These strategies are generally based on voluntary initiatives with varying sources of funding. However, it has to be recognised that due to the newness of the topic, there are only a limited number of analyses of regional adaptation, thus making the sample size of strategies small and by no means comprehensive.

4. Mitigation policy

The main aim of mitigation policy, and the ultimate objective of the UNFCCC as detailed in Article 2, is to achieve stabilisation of greenhouse gas (GHG) concentrations in the atmosphere that would prevent dangerous anthropogenic interference with the climate system (Rogner et al. 2007). Stabilisation should be achieved within a time frame that allows ecosystems to naturally adapt to climate change in order to secure food production and enable economic development to continue in a sustainable manner. Reaching a decision on what is dangerous interference with the climate system is a complex task and one that involves not only scientific judgement but also normative deliberations (Rogner et al. 2007). At the heart of this, is the dilemma between stabilisation of emissions and recognising the risks of climate change and thus potentially implementing measures that can threaten economic sustainability. It is acknowledged that as of yet, there is little consensus of what constitutes anthropogenic interference with the climate system and how Article 2 of the Convention can be operationalised (Rogner et al. 2007).

Currently, the total annual emissions are rising, with carbon dioxide emissions from the use of fossil fuels growing at a rate of 1.9 percent per year (Rogner et al. 2007). Considering that developing countries are likely to pursue increasingly intensive processes of industrialisation, this upward trend of emissions is likely to continue. It is projected that should there be no substantial change in energy policies globally in the coming decades, more than 80 percent of the energy supply globally will be based on fossil fuels, resulting in 40-110 percent increase in emissions compared to the year 2000. Overall, significant increases in emissions are estimated for 2030, and the most recent estimates predicting even higher rises than the earlier projections.

There have been several important steps globally to implement Article 2, most important of which is the entry into force of the Kyoto Protocol in February 2005. Although it is admitted that even the most efficient mix of well defined and executed climate policies can potentially be insufficient to curb emissions overall, the need for combining climate policies and sustainable development is underlined. In terms of the global agreements, the UNFCCC and the Kyoto Protocol have been the most important policy measures to deal with climate change. The future of which is currently hotly debated in anticipation of the Copenhagen Climate Summit in December 2009.

In addition to these, there are other agreements that can contribute to the reduction of emissions, such as the Asia-Pacific Partnership of Clean Development and Climate (APPCDC) established by a number of countries in the Asia-Pacific area. Similarly, the EU has signed agreements with China and India in order to enhance the deployment of clean and more efficient technologies. In addition to this, there are several bilateral agreements between countries that contribute to the reduction of emissions. In terms of success and effectiveness of climate policy, within the EU, The Fourth Assessment Report argues that experiences within the Union have demonstrated that while climate policies have been effective, they have often also been difficult to fully implement and coordinate, and require continuous improve to achieve the agreed objectives (Rogner et al. 2007).

The focus in report is to analyse mitigation policy in the European regions. In order to do that it is necessary to briefly present the EU policies on mitigation and how they affect the Member States as well as the regions within in them. Firstly, this section outlines the EU policy on mitigation after which a brief review of country approach towards mitigation within the EU are presented. This section concludes with a review of regional examples of mitigation policy.

4.1 European Union mitigation policy

The EU re-established its position in terms of mitigation and climate policy in 2007, when the European Parliament adopted the resolution on climate change in February (Commission of the European Communities 2008). Furthermore, the agreement by the European council to set legally binding targets to reductions of emissions in March 2007 signalled the determined position to set a leading example in terms of global climate change policy. A comprehensive package of mitigation measures was put forward by the European Commission in 2008. The EU Climate Change and Energy Package 2020 presents measures to deliver on the ambitious targets set (Commission of the European Communities 2008). The package outlines two main measures and one complementary one. Furthermore, the package sets out the contribution expected from each Member State to meet the targets and proposes policies and measures required to achieve them.

The first target outlined is for the EU to reach a reduction of at least 20 percent of greenhouse gases by 2020. This target is to rise up to 30 percent, if there is an international agreement committing other developed countries to comparable reductions. The second target outlines that 20 percent share of the Union’s energy consumption should be provided by renewable resources. Finally, the Climate Change and Energy Package states a goal of 20 percent saving of energy consumption by 2020 through measures that enhance energy efficiency in the transport, building and power generation, transmission and distribution sectors. The targets outlined in the Package rely on principles that aim to ensure that the targets are met simultaneously ensuring that costs are minimised. Furthermore, it is recognised that the efforts required from different Member States must be fair, taking in to account that some States are more able to meet the required targets than others.

The tools to achieve the targets centre around the Emissions Trading System (ETS), a market based system that provides incentives for cutting emissions in the Member States. Thus far, companies have received allowances from national governments and companies have then been able to trade the allowances, according to whether they have managed to keep their emissions below their own allowance level. The Climate and Energy Package 2020 does, however, realise that the ETS needs to be strengthened and updated if the objectives are to be met. It is acknowledged that the current form of the ETS runs the risk of distorting the functioning of the internal market and competition. The main measures to improve the ETS are to extend the scope of the trading system to include greenhouse gases other than CO , as well as including of all major industrial emitters. In addition, a harmonised ETS covering the whole Union will be most suited for a common market within the Union. Finally, the access to the Clean Development Mechanism (CDM) will be limited as this might undercut the efforts to reach the renewable energy target.

It is stated that the increase in the use of renewable energy can contribute not only to the reduction of greenhouse gas emissions but also to improve the energy security of the Member States. The current levels of renewable energy consumption are at 8,5 percent of total energy consumption, and it is calculated that an increase of 11,5 percent is needed on average to meet the targets (Commission of the European Communities 2008). In order to achieve the target set on renewable energy, investment is necessary on a major scale across the Union.

Most importantly, as with the ETS, it is recognised that the Member States enjoy different possibilities to deploy and develop renewable energy and the targets should be fair according to the ability of the Member State. Thus, half of the additional effort to reach the renewable energy target is shared equally between the Member States, whilst the other half is modulated according to GDP per capita. Furthermore, the targets are modified to take into account the increases in the share of renewable energy in the recent years. The emphasis placed on different sources of renewable energy can be decided by the Member States themselves whether the potential of individual countries is favourable to solar or wind power or biomass. Each Member State is required to put together a national action plan that sets out the details of how they will intend to meet the targets. Members States are also able to meet their targets outside their own borders, thus hopefully leading to more efficient production of energy.

Finally, The Climate Change and Energy Package recognises the use of biofuels as the only viable alternative transport fuel is acknowledged, and a scheme is proposed that aims to ensure that the increase of the use of biofuels does not lead to environmental disadvantages as a consequence of land use change and changes in biodiversity. For future options, technological solutions for reduction of emissions are considered important, and carbon capture storage (CCS) is considered to be an option (Commission of the European Communities 2008). Here the emphasis is on construction of demonstration plants by 2015 that can develop the technologies that can be used to reduce emissions even though fossil fuels are used.

Actual EU level policy instruments and directives that influence national level policy making in terms of mitigation were initially explored in the first European Climate Change Programme (ECCP I) that was launched by the European Commission in 2000 in order to identify common policies and measures within the Union that can be used to achieve the Kyoto targets. The second ECCP (II) was launched in October 2005 to review the first programme and explore new policy areas and instruments (EEA 2009). In line with the agreement on the Climate Change and Energy Package in 2009, these measures are now being implemented or are in advanced stages of preparation. For a complete list of key common coordinated policies and measures, see Annex 1.

4.2 National level mitigation policy across Europe

The IPCC Fourth Assessment report lists different national policy options for countries that can be used to achieve the reduction targets (Gupta, S., Tirpak, D. A. et al. 2007). Firstly, regulations and standards are the most common implements for environmental regulation. These instruments mandate specific technologies for carbon capture and storage or the level of emissions, for example. Secondly, instruments that can be used are taxes and charges, which require emitters to pay a fee according to greenhouse gases they have emitted. Furthermore, one way to curb emissions is to design a system of tradable permits around a particular sector of the economy or to the entire economy, the EU ETS being a good example of this covering several countries. Fourthly, voluntary agreements are made between the government and third sector actors or businesses in order to introduce and encourage mitigation of emissions. Fifthly, subsidies and incentives, such as investment tax credits can help to reduce emissions, although they can also have strong market implications. Research and development can also contribute to the transformation towards low carbon economies. In addition, public information campaigns and other information instruments can also lead to the mitigation of emissions through raising public pressure and awareness. Finally, there are non-climate policies that influence a country's GHG emission balance. These include land use, transport and trade, energy supply and agriculture. In general, it is considered that a policy that increases the use of natural resources is likely to increase emissions (Gupta, S., Tirpak, D. A. et al. 2007).

It is argued that a combination of these policy instruments is likely to mitigate emissions and contribute to sustainable development. Furthermore, these policies should be tailored to national circumstances. The selection of policy instruments can be based on a criterion that is composed of the principles of environmental effectiveness, cost-effectiveness, distributional considerations and institutional feasibility (Gupta, S., Tirpak, D. A. et al. 2007). A recent study commissioned by the European Parliament's Temporary Committee on Climate Change examined national legislation and national initiatives and programmes that relate to climate change in the Member States (Geeraerts et al. 2007). Information on the various pieces of legislation, initiatives and programmes was collected with a questionnaire that was sent to the national parliaments by European Parliament. For the main results, see Annex 2. As the details of each country in terms of their initiatives within each sector can be quite vast, Annex 2 only summarises the key findings. For information on all countries, the reader is directed to the original publication.

4.3 Regional level mitigation policy in Europe

As argued earlier in this review, the regional level is affected by policy initiatives on other levels of governance and this is also true with regards to mitigation. In addition to steering coming from other levels of governance, there are regions and local actors that have begun preparing their own strategies, developing their own guidelines with regards to mitigation and adaptation. There have been a few studies to analyse how this plays out in climate policy, focusing on the coherence and coordination of policies on different levels of governance. This section firstly summarises research findings from these and secondly introduces a few regional climate strategies within Europe.

The study by Monni and Raes analyses the opportunities and barriers of multilevel decision-making, by concentrating on the implementation of EU directives at the national level in Finland and at regional level in the Helsinki Metropolitan Area Council (Monni, Raes 2008). It is recognised that although the lower levels of government might not have legislative powers, they still make important decisions related to land use, transport and building regulations. The study analyses four of the EU directives that are set to achieve reductions of emissions during the Kyoto Protocol until 2012, namely the directives on renewable electricity (2001/77/EC), cogeneration (2004/8/EC), energy performance of buildings (2002/91/EC), biofuels for transportation (2003/30/EC) and landfills (1999/31/EC).

The results indicate that within the case study example, there are contradictions in terms of the objectives set by the EU directives and endorsed by the Finnish government and the city non-action towards increasing the use of renewable in energy production on the other hand (Monni, Raes 2008). For example, although there have been moves towards renewable energy use in other sectors, energy production continues to heavily rely on natural gas and coal. This results in the city of Helsinki essentially free riding when one considers the need to achieve the reduction targets in the whole country. Furthermore, promotion of renewable energy at the national level is based on tax and investment subsidies which appear to be not enough to encourage investments in Helsinki. However, in general, it is argued that the climate policy of Helsinki complements the policy outlined by the EU and the national policies. There are also areas within which Finland has been ahead of EU policy and where directives have not meant significant changes.

Similar challenges of multilevel policy with regards to renewable energy have been identified in the UK (Smith 2007). The promotion of renewable energy is happening through national, regional and local networks of businesses and non-state actors in partnership with policy-makers on those levels. Smith identifies both “ordered” and “messy” forms of governance (Hooghe, Marks 2003) within the English regions (Smith 2007). On the one hand, regions have pursued regional renewable energy governance through regional strategies and the authority given by them. This has meant that direct national policy goals and guidelines are implemented to some extent at the national level. On the other hand, the examples emerging from the case study can be characterised as messy in the sense that governance takes place through regional policy networks in the absence of real authority at the regional level. Progress in terms of regional renewable energy policy is furthered hindered by the unwillingness of the national level to empower the regional level (Smith 2007).

In addition to activities and policies that affect the regional level, there is also a trend towards regional climate strategies through which regional actors aim to reduce their greenhouse gas emissions. There are a few initiatives that aim to bring together a selection of best practice cases that can act as examples within Europe. Since the publication of the EU Green Paper in 2007, the Assembly of European Regions (AER) launched a Working Group on climate change. The objectives of the Working Group are considered to highlight the role of the regions in this issue by bringing together regional best practices that contribute mitigation but also to adaptation. See details of best practice cases within the regions in Table 2. Many of these strategies feature both mitigation and adaptation in their approach but have a predominantly adopted mitigation as their main goal.

Table 2 Examples of regional mitigation and adaptation strategies.

Region	Details
Catalunya's environmental strategy to tackle Climate change (E)	The document details the various actions undertaken by the Generalitat de Catalunya in order to mitigate climate change (for instance in transport, urban planning, energy, agriculture...) and adapt to the already existing effects (water management, biodiversity)
Hampshire (UK)	The documents presents 3 projects, entitled ESPACE, Climate Change Commission and Hampshire & Isle of Wight Sustainable Business Partnership, along with a series of key messages on the county's policy on climate change
Örebro's Energicentrum project (S)	Documents present its latest energy project, which contributed to the overall strategy to mitigate climate change in the region
Midi-Pyrénées' Regional Climate Plan (F)	Strategy aims at mitigating climate change thanks to a Regional support scheme dedicated to RES, energy efficiency, clean transport and eco-building. Particularity: regional programme entitled: "economical and sustainable social housing"
Limousin's regional wind energy scheme and climate plan (F)	The Regional Council of Limousin has set up a regional wind energy project, as well as an overall strategy on sustainable social housing. A climate strategy is currently being defined
Comunitat Valenciana's project (ES)	The objective is to realise simulations of heat waves and cold invasion and improve the region's capacity to foresee climate sudden variations
Dorset's climate change policy (UK)	Dorset's Carbon Management Action Plan for Mitigation and Local Climate Impacts Profile for Adaptation along with the region's projects
Norrbotten (SE)	The county council's strategy to improve sustainable economic growth, address climate issues and environmental challenges.

Source: (AER 2009).

Similarly, the Environmental Conference of the European Regions (ENCORE) established a virtual Climate Change working group that has details of 19 European regions and their mitigation and adaptation measures. See Table 3 for details of the best practice cases listed.

Table 3 Best mitigation practice cases.

Region	Details
Vienna, Austria	The Urban Energy Efficiency Programme (SEP) comprises and co-ordinates more than 100 single measures, providing guidelines for the city's consumer-side energy policy until 2015.
Schleswig-Holstein, Germany	Biomass and Energy project was begun in 1996 and several pilot- and demonstration projects for the use of biomass. Until the end of 2007, emissions had been reduced by 414.000 t CO_2 annually.
Häme and Päijät-Häme, Finland	Sustainable future for the Region. The objectives of the projects were to promote sustainable development, to increase co-operation among residents, NGOs, companies and the administration and to assess the progress toward sustainable development in six municipalities in the Hämeenlinna region.
Aragon, Spain	Green purchases project that aims green purchases in products and services and Stop climate change: Act with energy! programme that started in Nov. 2004 and aims to create awareness among the Aragonese general public about the problems of climate change. It creates a forum for debate and meeting in which all the Aragonese associations and sectors participate.
Jämtland, Sweden	Biomass-fired power heating plant in Östersund that aims to contribute to regional development and to supply high-quality energy and services at consistently low prices.

Source: (ENCORE 2009).

5. Adaptation policy

Adaptation is considered to be the second policy response alongside mitigation in relation to the challenges posed by the changing climate. Adaptation has been defined as the processes, practices and structures to moderate or offset the potential damages of opportunities associated with climate change (Smit, Pilifosova 2001). The internationally accepted definition by the Intergovernmental Panel on Climate Change (IPCC) considers adaptation as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC 2007).

Adaptation can take place through autonomous adaptation by individuals or by business for example. Alternatively, planned adaptation can take place through public policy measures undertaken by governments in order to avoid harm due to climate change or to exploit the possibilities that arise from the changes. In addition to this distinction, adaptation policy can also be reactive, focusing on impacts that have already been felt due to climate change. In contrast, adaptation can also be proactive in that adaptations are developed and designed to counter the effects of projected changes. The main challenges of adaptation to climate change are the sectoral coordination of policies as well as policy integration of adaptation policy across policies in individual sectors (Mickwitz et al. 2009).

The focus in this report is on planned adaptation policy, and in the context of adaptation policy within the European regions. However, it is important to note that governance of other levels within the European Union, namely the national and the EU level, affects the adaptation policy in the European regions. The individual governance frameworks of countries enable or constrain regions to adapt to climate change. Also, the extent to which land use planning and other decisions related to adaptation are taken at the local level inhibits the regions to engage in adaptation. Therefore, in order to understand adaptation policy at the regional level in Europe, it is necessary to detail the approach to adaptation on other levels of governance also.

5.1 European Union Adaptation Policy

The European Union White Paper on adaptation was published in 2008 (Commission of the European Communities 2009). The White Paper emphasises the need for a strategic approach, recognising that adaptation is already taking place across several member states. The White Paper complements the national initiatives that are taking place and aims to support international efforts of adaptation, also particularly in developing countries. It is stressed that action at the EU level is necessary, although most of the adaptation measures will be taken at the national, regional or local level. This is because the EU has a particularly strong role in instances where climate impacts transcend the boundaries of member states as well as making sure that the most disadvantaged regions will be capable of taking measures needed for adaptation. The role of the EU in coordinating action across certain sectors, such as agriculture, water and biodiversity are seen important and can be implemented by using the single market and common policies.

The objective of the EU's Adaptation Framework is to improve the resilience of the Union to deal with the impacts of climate change by adopting a two-phase approach (Commission of the European Communities 2007). First phase from 2009-2012 is to lay the groundwork for the preparation for a comprehensive EU adaptation strategy that will be implemented in the second phase, beginning 2013. Phase 1 consists of four pillars of action that require close co-operation between the EU, national, regional and local authorities in order to be successful, see Table 4. First pillar consists of developing the knowledge base for adaptation that is based on reliable data on not only the likely climate change impacts but on related socio-economic aspects, including the costs and benefits of different adaptation options. Secondly, it is necessary to integrate adaptation into existing EU policies by conducting a review of how policies could be re-focused or amended to facilitate and enable adaptation. Thirdly, it is important to consider employ a combination of policies and policy instruments, ranging from guidelines to market-based instruments. Finally, the EU needs to step up and improve its role in international co-operation on climate change.

Table 4 EU Adaptation Framework: Phase 1.

Pillars of action	
Developing of the knowledge base	Take the necessary steps to establish by 2011 a Clearing House Mechanism Develop methods, models and data sets and prediction tools by 2011 Develop indicators for to better monitor the impact climate change, including vulnerability impacts, and progress on adaptation by 2011 Assess the costs and benefits of adaptation options by 2011
Integration of adaptation into policies	Develop guidelines and surveillance mechanisms on the health impacts of climate change by 2011 Step up existing animal disease and control systems Assess the impacts of climate change and adaptation policies on employment and on the well-being of vulnerable social groups
Policy instruments	Estimate adaptation costs for relevant policy areas so that they can be taken into account in future financial decisions Further examine the potential use of innovative funding measures for adaptation Explore the potential for insurance and other financial products to complement adaptation measures and to function as risk sharing instruments Encourage Member States to utilise the EU'S ETS revenues for adaptation purposes
Member State and International co-operation	Take a decision to establish by 1 September 2009 an Impact and Adaptation Steering Group (IASG) to step up cooperation on adaptation Encourage the further development of National and Regional Adaptation Strategies with a view to considering mandatory adaptation strategies from 2012 Step-up efforts to mainstream adaptation into all EU external policies Strengthen dialogue with partner countries on adaptation issues Take the Framework for Action on Adaptation forward in the UNFCCC

Source: (Commission of the European Communities 2009)

In terms of supporting European regions in their efforts to adapt to climate change, the EU plays an important role. Coordination of adaptation by the EU is considered to be important in order to avoid major gaps in trans-national linkages and to provide common strategic direction to achieve a coherent approach to adaptation within the Union (Ribeiro et al. 2009). There are existing tools that can be used to support the regions' development of RAS, the most important of which is funding from existing EU funding mechanisms. Activities that can be supported from the funds include knowledge development, testing and validation of knowledge development, monitoring of the RAS development, its implementation and generation of awareness amongst relevant stakeholders as well as amongst the general public (*Ibid.*). The existing mechanisms that can be used include the regional development, economic and social cohesion funds, such as the European Regional Development Fund (ERDF), The European Social Fund (ESF), LIFE + and INTERREG funding, for example.

5.2 National level adaptation policy across Europe

As the White Paper recognises, national level initiatives on adaptation have increased rapidly in the last few years within the European Union. There are now ten member states within the EU that have adopted a NAS, whilst several states are in the process of developing one, see Table 5 for countries that have a NAS. The Table also has details of countries that have yet to adopt or are not in the process of pursuing one. According to the European Environment Agency, the status of development of the NAS within the Union depends on the magnitude and nature of observed impacts, assessments of current and future vulnerability as well as the capacity of the countries to adapt to climate change (European Environment Agency 2009).

Table 5 European countries that have adopted a NAS.

Countries	NAS adopted	Countries without a NAS
Austria	(expected in 2011)	Czech Republic
Belgium	(expected in 2012)	Iceland
Denmark	2008	Liechtenstein
Estonia	(expected in 2009)	Lithuania
Finland	2005	Luxembourg
France	2006	Poland
Germany	2008	Portugal
Hungary	2008	Romania
Ireland	(expected in 2009)	Slovak Republic
Latvia	(expected in 2009)	Switzerland
Netherlands	2008	Turkey
Norway	2008	
Spain	2006	
Sweden	2009	
United Kingdom	2008	

Source: (European Environment Agency 2009)

There have been a few studies of adaptation measures and strategies at the national level within the developed world, including the EU. Gagnon-Lebrun and Agarwala analyse the progress and trends of implementation of adaptation in Annex I countries of the UNFCCC (Gagnon-Lebrun, Agarwala 2006, Gagnon-Lebrun, Agarwala 2007). In order to do this, the authors chose to use the NCs as their main source information, as they represent, as discussed above, a source of comparable information from all the parties to the Convention. Progress on adaptation is analysed firstly by focusing on how adaptation has been addressed in terms of policy concerns and measures. Secondly, the article presents the results of an assessment of progress made by countries in the implementation of adaptation.

Gagnon-Lebrun and Agarwala assess the countries based on three criteria, namely the assessment of impacts and vulnerability, identification of adaptation options and implementation of measures, and thirdly, establishing institutional mechanisms to support the above two. The results of the first task show that adaptation issues discussed in NC2 and NC3 are fairly limited, with only a handful of countries discussing specifically addressing adaptation. More emphasis has been placed on impacts and vulnerability to climate impacts in the majority of the NCs. However, there are countries, such as Spain, Liechtenstein and the Netherlands that have broader coverage of adaptation in relation to the impact assessment. The only country that has equal coverage of the three factors is the United Kingdom.

In order to assess the progress on adaptation actions, Gagnon-Lebrun and Agarwala distinguish between intentions and actions, which are further divided into the establishment of institutional mechanisms, formulation or modification of existing policies and the incorporation of adaptation measures at the project level (Gagnon-Lebrun, Agarwala 2007). Three categories of countries are identified, depending on what the level of adaptation actions are. Firstly, there are countries that have early to advanced stages of impact assessment but adaptation is not discussed in the NCs. Countries in this category include, for instance, Hungary, Iceland, Portugal and Latvia. The second category consists of countries that have been very advanced in terms of impact assessment, but have been slow in introducing adaptation measures in that discussion of adaptation options is limited. Countries here comprise of Czech Republic, Estonia, Denmark, Austria, Germany, Greece, Italy, Liechtenstein, Luxembourg and Norway. The final category of countries, ones with advanced impacts assessments and who are moving towards implementing adaptation, is an interesting one. Gagnon-Lebrun and Agarwala argue that in fact no developed country has yet to formulate a comprehensive approach, although the UK might come close. For other countries in this category that come close formulating a comprehensive approach to climate change, see table 6.

Table 6 EU countries advanced on adaptation.

Countries moving towards adaptation	Belgium, Finland, France, Ireland, the Netherlands, Poland, Spain, Switzerland, Sweden, the UK

Source: (Gagnon-Lebrun, Agarwala 2007)

As the adaptation policy field is a very fast moving one, an analysis of NAS and adaptation policy can be quickly out of date. A recent analysis of adaptation policies across Europe focused not only on the level of adaptation but also on the objectives of adaptation, as well as aims of adaptation (Massey, Bergsma 2008). Adaptation level is considered to be how far each country has advanced in term of policy activities. The objectives of adaptation are analysed in terms of why or for what reason a country is undertaking adaptation initiatives. Thirdly, the aim of adaptation strategies and measures is assessed in terms of what the vulnerable sectors and domains are the strategies and measures are directed at. Data for the exercise is drawn from UNFCCC country reports, as well as from official government reports that were available in English. In terms of leaders and laggards of European adaptation policy in terms of policy concerns, recommendations and measures in alphabetical order, see Tables 7 and 8.

Table 7 Leaders of adaptation levels in Europe.

Concerns	Recommendations	Measures
Belarus	Bulgaria	Belgium
Denmark	Czech Republic	Germany
Portugal	Finland	Italy
Norway	France	Netherlands
Sweden	Germany	Switzerland
Switzerland	Slovakia	United Kingdom

Source: (Massey, Bergsma 2008)

Table 8 Laggards of adaptation levels in Europe.

Concerns	Recommendations	Measures
Bulgaria	Estonia	Croatia
Finland	Hungary	Finland
France	Ireland	Hunagry
Italy	Italy	Poland
Latvia	Norway	Romania
Poland	Portugal	Slovakia
Romania		Slovenia
United Kingdom		Spain
		Turkey

Source: (Massey, Bergsma 2008)

In terms of percentage of implemented adaptation policy measures, according to Massey and Bergsma, Western Europe is the most advanced of the socio-economic regions, closely followed by Southern Europe (Massey, Bergsma 2008). Northern and Central Europe are more advanced in terms of policy recommendations. In terms of the adaptation level, the report also analyses different physiographical regions that enables one to focus on adaptation within a region rather than across regions.

Massey and Bergsma further divide adaption objectives into four categories; see Table 9 (Massey, Bergsma 2008). For all socio-economic regions, Western, Northern, Southern and Central Europe, the main objective is risk and sensitivity reduction. In addition, a little more emphasis is placed on extreme events where as capitalising on opportunities receives a little more attention in Central European adaptation strategies.

Table 9 Adaptation objectives.

Adaptation objective	Details
Building adaptation capacity	Actions related measures that build or enhance governance or societal awareness on adaptation
Reduction of risk and sensitivity	Actions that reduce the risk of damage and reduce sensitivity, implying pre-emptive action
Increasing coping capacity during extreme events	Actions that focus on enhancing the capacity to cope during extreme events
Capitalisation on changed climatic conditions	Actions that will yield benefits arising from climate change

Source: (Massey, Bergsma 2008).

For the physiographic regions[2], the Alpine region reduction of risk and sensitivity are the most important features but capitalisation on climate change is also an important feature. Within the Tatra and Carpathian region, risk and sensitivity reduction feature heavily but on the other hand, no attention is paid on building of adaptive capacity or coping capacity, for example in Czech Republic and Slovakia. Within the Atlantic region, the UK is a leader in all categories, with France and Spain having the most measures in terms of building adaptive capacity. The North Sea region is heavily focused on reduction of risk and sensitivity with over half of the measures in all countries within this category. In addition, Sweden and Denmark have placed most emphasis on capitalisation on climate change. In the Baltic Sea region, Finland and Poland have the most even coverage of all four categories, whilst building of adaptive capacity is relatively low in Germany. In the Mediterranean region the objectives are quite diverse across the region but overall there is less emphasis on enhancing adaptive capacity in relation to the other physiographic regions. In the Black Sea region, there is very little emphasis on adaptive capacity again with most measures targeted towards reducing risk and sensitivity.

[2] Physiographic regions were Alpine, Tatra & Carpathian, Atlantic, North Sea, Baltic Sea, Mediterranean, and Black Sea. Some countries were analysed in more than one category in order to get a comprehensive view of a particular region. For example, the UK was part of both the Atlantic region and the North Sea region.

Targeted domains, in terms of what adaptation measures are aimed at, are also analysed by Massey and Bergsma (Massey, Bergsma 2008). The report outlines ten areas, drawing on the UNFCCC NCs and the Finnish NAS. These are coastal zone management, landscape management, water management, extreme temperature, energy, biodiversity management, financial management, health and disease management, agriculture, and food security and development co-operation. All socio-economic regions consider the landscape and water management as priority sectors. Food security and agriculture feature heavily in the Central European strategies, whilst biodiversity management receives attention in Northern Europe. In terms of the physiographic regions and their adaptation aims, see Table 10.

Table 10 Adaptation aims across physiographic regions.

Region	Aims
Alpine	Landscape and water management most important, followed by biodiversity management and food security
Tatra and Carpathian	Food production and security most important tailed by water management
Atlantic	Landscape management and water management most important followed. Interestingly no explicit emphasis on coastal zone management
North Sea	Dominant aims landscape management and water management; coastal zone management addressed but varies between countries
Baltic Sea	Landscape, water and coastal zone management dominate, followed closely by biodiversity management and food security
Mediterranean	Relatively diverse portfolios across the region, food security and landscape management most dominant
Black Sea	Water management and food security are considered important, otherwise fairly narrow focus

Source: (Massey, Bergsma 2008).

Adaptation at the national level has also been analysed in project that assessed adaptation policies at the national level in more detail (Swart et al. 2009). The Partnership for European Environmental Research (PEER) Report compared European NAS in ten countries; see Table 11 for more information on the countries and their respective strategies. The report is structured around six key themes that were considered to be relevant by the research teams, and each country's approach to adaptation within these themes is analysed. Firstly, the report analyses the motivating and facilitating factors for NAS development. Secondly, the role that research plays in the development of adaptation policy is analysed, as well as the role of communication in the NAS across the different countries. Fourthly, aspects of multilevel governance were explored within the project, relating to the vertical linkages between levels of governance. Fifth, integration of adaptation into sectoral policies is considered a vital research area. Finally, the role of monitoring, evaluation and enforcement of adaptation policy was deemed worth focusing on.

Table 11 Details of selected NAS in Europe.

Country	Details
Denmark	The government introduced the strategy in 2008. The Danish Strategy places emphasis on autonomous adaptation in all spheres, including enterprises and individuals. Implementation is to be supported by information initiatives, a research strategy and facilitation in planning and development. The strategy also outlines the challenges faced by the most vulnerable sectors.
Estonia	Estonia's NAS is expected to be completed in 2009.
Finland	NAS process was begun in 2003 and published in 2005. The NAS outlines vulnerable sectors and suggests further improvement of knowledge base and recommendations for adaptation measures. The NAS is to be implemented by each Ministry within their sector. So far, the Environment Administration has made most progress. The NAS was evaluated in 2009 and it was concluded that the need for adaptation has been recognised by many sectors and some adaptation measures have already been implemented.
Germany	The NAS was adopted in December 2008. The NAS aims to integrate the work that is already been conducted in various ministries and establish a transparent mid-term review. Major knowledge gaps are identified and responsibilities of all levels of government are identified. The NAS also has inbuilt systems for monitoring and evaluation.
Norway	Scoping study for adaptation was published in 2004. In 2008, the government published a draft consultation on three main objectives; mapping of vulnerability, enhance understanding about adaptation and climate change, and stimulate information and capacity building. A cross-cutting report (13 Ministries) published in 2007 detailing the vulnerabilities of the country.
Latvia	An informative report was submitted to the government in 2008, which will serve as a base for the NAS. A NAS is under preparation by two working groups and will focus on integration of adaptation into existing policies.
Sweden	Sweden will not produce a NAS but has drafted a Climate Bill that effectively aims to integrate and coordinate responses between vulnerable sectors. The Climate Bill is based on the report by the Climate and Vulnerability Commission that summarises all the challenges that Sweden faces and offers a concrete set of proposals.

Source: (Swart et al. 2009).

The project results show that there a multitude of motivating factors that have enabled adaptation at the national level (Swart et al. 2009). These have included the international climate negotiations processes, experiences of extreme weather events and research on climate change to name a few. Furthermore, the existence and availability of climate information was crucial in advancing the national developments on adaptation. There are different stages of development that countries undertake climate change related research, ranging from the physical climate science data to more socially scientific analyses of vulnerabilities and adaptation options. The further ahead the country is on climate research, the stronger the possibility is that the country has considered adaptation. Communication is seen as a cornerstone of a successful NAS but there is yet little evidence of how climate information is effectively communicated to different actors across sectors public administration and other stakeholders.

Multilevel governance is recognised as of crucial importance in the PEER Report (Swart et al. 2009). There is little mention of the international level or the EU level in the existing NAS. Most of the analysed NAS do, however, acknowledge the need to take adaptation measures at the local or at the regional level. Despite this, there is a lack of clarity in terms of roles and responsibilities across levels in many of the countries studied. Many of the NAS identify sectoral integration of adaptation into policies a key challenge but offer very few solutions in order to achieve this. Open questions that remain are how can adaptation actions be designed, organised and financed? Finally, as the NAS processes are fairly new they stress the necessity to have evaluation and review of policies in place but as yet do not offer means to assess the effectiveness of adaptation strategies.

As of yet, there have been relatively few analyses of adaptation across multiple scales of governance. The EUR-Adapt project O*rganising adaptation to climate change in Europe* focuses on adaptation policy development and actions in four European countries, Finland, Italy, Sweden and the UK (Keskitalo 2010). The project findings have indicated that adaptation has emerged in all the countries mainly through international processes at the national level, whilst weather impacts have contributed to the actions on adaptation on the sub-national levels (Keskitalo, Westehoff & Juhola submitted). The approach that countries take on adaptation is also depended on the framing of adaptation in terms of who is responsible and what adaptation measures should consists of (Juhola, Keskitalo & Westerhoff Submitted). Finally, in terms of adaptive capacity, different levels of governance vary and different capacities are needed on different levels of governance in order to push the agenda on adaptation forward (Westerhoff, Keskitalo & Juhola Submitted).

5.3 Regional level adaptation policy in Europe

Regional initiatives on climate change adaptation, or regional adaptation strategies (RAS) are a relatively recent development in Europe and there are even fewer studies of them than of NAS. The regional approach is considered to extremely crucial because the severity of climate change impacts will vary from region to region across the continent, and is dependent on the physical conditions of the region, degree of socio-economic development and response mechanisms of the region. Regions play an important role in terms of regulating issues related to built environment, building and maintenance of infrastructure in terms of drainage and piped water, and provision of services, such as fire protection, public transportation and disaster response. The role of regions is not merely limited to the normal maintenance but also should include long-term maintenance, pre-disaster damage limitation, immediate disaster response and rebuilding (Gagnon-Lebrun, Agarwala 2006).

Thus far, there have been a limited amount of studies that have analysed the emergence and content of regional adaptation strategies, mainly due to the reasons that regional initiatives are even more recent than the national ones. Secondly, examining adaptation policy at the regional level across countries or even within one country presents its own methodological challenges. It has been admitted that even national level data can be hard to come by with the UNFCCC country reports presenting the only fairly consistent source of information about adaptation policies in a particular country. Ribeiro *et al*. present some challenges for data availability for analysing regional level adaptation, including the fact that information of measures is almost always only available in the local language and they may not be always easily available across countries (Ribeiro et al. 2009).

The emergence of regional adaptation can be interpreted to be happening through two processes. Some regional strategies are happening because of strategy processes at the national level and as a response to them. At the same time, regional processes are occurring concurrently to the national ones within regions that are forward thinking in terms of climate change and have acquired resources and are able to pursue their own goals irrespective of the actions undertaken at the national level. It is expected that in the future, regional strategies for adaptation will become more important as countries are further developing their approaches and clarifying the roles of responsibilities in terms of adaptation measures.

The development of RAS is hindered by the uncertainties on the scale, timing and consequences of climate change, as well as lack of information, knowledge and expertise at the regional as well as local level (Ribeiro et al. 2009). A study of existing RAS is one of the first attempts to analyse and develop guidelines for regional adaptation. Riberio *et al.* study 31 RAS in six selected countries (France, Germany, the Netherlands, UK, Sweden, Spain). The case studies were chosen on the basis of an internet survey, interviews and assessment of published reports. The analysis was divided into two phases, the first phase analysing the strategies holistically in terms of the strategies themselves, their preparation process and the information that was used to design them.

Secondly, the each strategy was analysed in terms of the individual actions that were proposed in it and these were further categorised.

The results of the assessment show that regional strategies fore mostly emerge as a response to particular social vulnerabilities, including extreme weather events (*Ibid.*). According to the analysis, most of the RAS so far are concentrated in Northern and Western Europe, and in countries that have a NAS, with the exception of Sweden. Many of these countries have been active in mitigation policy and have had strong commitments to environmental policy in general. An interesting linkage can be observed between regional initiatives and collaborations with the scientific community, examples of this can be seen areas such as transnational river basin, the Baltic Sea region, and the Alps, for example.

The key lessons drawn from the analysis of existing RAS highlight the following issues (Ribeiro et al. 2009). There are two types of regional processes emerging, firstly, those involving sub-national governments with varying degrees of autonomy, Länder in Germany or Communidades Autonomas in Spain, for example. On the other hand, there are larger cities or urban areas that are pursuing their strategies, for instance London and Paris. Some city level adaptation strategies can also be termed as local adaptation strategies (LAS). Also, many regional responses to climate change do not yet explicitly address adaptation but centre on mitigation or climate neutrality. Alternatively, RASs often incorporate both mitigation and adaptation measures, and are often considered to be climate change strategies, rather than mere adaptation ones.

Secondly, it appears that policy developments are evolving in an interactive fashion between the central and the regional government. This is because many of the countries where RASs were identified had already implemented their NAS. Some NAS explicitly provide a framework for the development of regional strategies, in the form of legal obligations or merely information and encouragement. Overall, however, it appears that there is limited guidance and steering from the national level in terms of regional action on adaptation. Moreover, there appears to be no overall mandate for requiring the development of RAS in any of the countries studied in the report. The UK Climate Bill comes closest to this were the national government can assess adaptation of local authorities through their performance in terms of the national indicators. What remains somewhat unclear in all the RAS, are the allocation of roles and responsibilities of different actors on different levels of governance within the RAS that were examined.

RAS often comprise and are developed on the basis of patchwork of climate information, resulting in strategies that vary in the quality of information on which adaptation options are based on (Ribeiro et al. 2009). In terms of stakeholder involvement in the drafting of RAS, there appears to be one organising and coordinating body at the regional level. This of course varies and there are different ways to involve stakeholders in the drafting of the strategy. The most popular methods of participation were consultation workshops, electronic and telephone consultations, cross-sectoral or sectoral working groups with societal participation. In many of the strategies, public consultation was only a component of the preparation process of the strategy. However, continuous participation was encouraged in the UK regions as well as in the Netherlands.

Although strategies have been pursued, it does not necessarily mean that all RAS include specific implementation measures that are already outlined in the strategy paper. Thus, the existence of a strategy does not necessarily guarantee action on adaptation. In their analysis of level of adaptation process RAS, Ribeiro *et al.* have utilised the division made by Massey and Bergsma (2009) outline earlier in this review. According to this division, policy actions can be divided into policy concerns, policy recommendations and policy measures. Out of the analysed RAS, many put forward general directions on how to respond to the climate challenge, expressing a level of concern. There are, however, strategies that explicitly put forward policy recommendations, particularly in relation to organising and informing the regional response, or setting up implementation bodies, and approximately half of the RAS analysed included these. Actual policy measures were put forward in less than 20 percent of the strategies (Ribeiro et al. 2009).

As one would expect, priority sectors in the adaptation strategies vary, according to which sectors are considered to be particularly vulnerable within a specific region. According to Miguel Ribeiro *et al.*, two particular sectors stand out, namely health effects of climate change and landscape management in terms of flooding, sea level rise and drought. Regional emphasis on adaptation varies, for example Paris emphasising heat wave related dangers where as regions of the Netherlands have identified flooding and water related issues as their main focus. Water supply and treatment, biodiversity management and food production and the agricultural sector were also popular focuses of the examined RAS.

In relation to the types of adaptation responses, 40 percent of the responses can characterised to be contributing to reduction of risk and sensitivity (*Ibid*.). Most of the RAS also acknowledge the limits of national government intervention, and recognise the need to build capacity at the regional level. Although a smaller amount of RAS outline potential future benefits arising from climate change, those that do focus on the tourism sector and consider climate change as an opportunity to improve water and land management within the region.

6. Conclusion

This report has reviewed mitigation and adaptation policy in Europe by taking multilevel governance as its starting point. Challenges of policy coherence, integration and coordination are significant challenges in both mitigation and adaptation. European regions and the policy options they are able to pursue are affected not only by national level policies but also by policies from the EU level. In addition, local authorities and municipalities have more influence and power in decision-making in some countries than others within the Union. These factors affect the way that mitigation and adaptation is designed, developed and implemented. In terms of mitigation policy, the legally binding targets are likely to cause adjustments in the national policy and consequently affect the regional level policy. Adaptation policy, in comparison to mitigation policy, is still being formed, and each of the Member States has been able to pursue their own strategy with little direction from the EU level thus far. An increasing trend within Europe has been the emergence of regional or local climate strategies that tackle both mitigation and adaptation together. These are often based on voluntary initiatives and are related to energy efficiency and concern for climate change in terms of mitigation, and local vulnerabilities to impacts of climate change in terms of adaptation.

Table 12 Key common coordinated policies and measures within the EU

Sector	Issue	Description
Cross-cutting	Effort sharing	Effort Sharing Decision: Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020
	EU Emission Trading Scheme (EU ETS)	Effort Sharing Decision: Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020
	Carbon capture and storage (CCS)	CCS Directive: Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006
	Kyoto Protocol project mechanisms	Linking Directive: Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms
	Integrated pollution prevention and control (IPPC)	IPPC Directive: Directive 2008/1/EC EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (recast of Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control)
	Green public procurement	Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts
Energy supply and use	Energy from renewable sources	RES Directive: Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (RES.e Directive: Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market, Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport)
	Energy end-use efficiency and energy services	Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive

		93/76/EEC
	Use of biomass, renewable heat	Biomass Action Plan: Communication from the Commission on a Biomass Action Plan, COM(2005) 628 final (adopted in December 2005)
	Ecodesign of energy-using products	Ecodesign Directive: Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy.using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council
	Cogeneration (combined heat and power)	Cogeneration Directive: Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC
	Energy taxation	Energy Taxation Directive: Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity
	Trans-european energy networks (TEN-e) and internal energy markets	Decision No 1229/2003/EC of the European Parliament and of the Council of 26 June 2003 laying down a series of guidelines for trans.european energy networks and repealing Decision No 1254/96/EC Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC Regulation (EC) 807/2004, Regulation (EC) 1228/2003
	Energy labelling	Commission Directive 2003/66/EC of 3 July 2003 amending Directive 94/2/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations Energy Labelling Directive: Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances
	Motor-driven systems	Motor Challenge Programme: European Commission voluntary programme launched in February 2003 to aid industrial companies in improving the energy efficiency of their electric motor-driven systems, focusing on compressed air, fan and pump systems
	Energy performance of buildings	Energy Performance of Buildings Directive: Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings
	Large combustion plants	LCP Directive: Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants (recast of Council Directive 88/609/EEC of 24 November 1988 on the limitation of emissions of certain pollutants

		into the air from large combustion plants)
Transport	Emission performance of passenger cars	Strategy for car CO2: Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light.duty vehicles Voluntary agreements with car manufacturers: Commission Recommendations of 5 February 1999 and 13 April 2000 on the reduction of CO2 emissions from passenger cars (voluntary agreement with car manufacturers from EU, Japan and Korea to reduce fleet average CO2 emissions to 140 g/km by 2008/2009)
	Energy efficiency	Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy.efficient road transport vehicles
	Transport fuels	Fuel Quality Directive: Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC
	Aviation	Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community
	HFC motor vehicle air conditioning	MAC Directive: Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air.conditioning systems in motor vehicles and amending Council Directive 70/156/EEC
	Biofuels	Biofuels Directive: Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport
	Modal shift towards rail	Rail Directives: Directive 2007/58/EC of the European Parliament and of the Council of 23 October 2007 amending Council Directive 91/440/EEC on the development of the Community's railways and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure Railway Safety Directive: Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification Directive 2004/50/EC of the European Parliament and of the Council of 29 April 2004 amending Council Directive 96/48/EC on the interoperability of the trans.european high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the

		interoperability of the trans‑european conventional rail system
Industry	Fluorinated gases	F‑gas regulation: Regulation (EC) No. 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases
Agriculture	Decoupling of support from production	CAP reform — transition to single farm payment (SFP): Council Regulation (EC) No 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending Regulations (EEC) No 2019/93, (EC) No 1452/2001, (EC) No 1453/2001, (EC) No 1454/2001, (EC) No 1868/94, (EC) No 1251/1999, (EC) No 1254/1999, (EC) No 1673/2000, (EEC) No 2358/71 and (EC) No 2529/2001
Waste management	Landfill	Landfill Directive: Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste
	Waste Framework Directive	Waste Framework Directive: Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives
Forestry	Sustainable forest management	EU Forest Action Plan: Communication from the Commission to the Council and the European Parliament on an EU Forest Action Plan, COM(2006) 302 final (adopted on 15 June 2006)

Source: (EEA 2009).

Table 13 National legislation and programmes related to climate change within the EU.

Sectors	Directive	National actions
Buildings energy performance	2002/91/EC of 16 Dec 2002	There is a diversity of approaches towards improving the energy performance of buildings. Austria makes housing subsidies conditional upon the achievement of energy standards which are clearly more ambitious than the minimum energy standards set out in building regulations. Belgium aims to encourage the construction and rehabilitation of passive houses through a tax deduction, whereas Italy has introduced an obligation to install photovoltaic panels in new buildings.
Biofuels in transport	2003/30/EC of 16 of Dec 2002	Some reported legislative pieces do not formally tranpose Directive 2003/30/EC, but have nevertheless been adopted to promote the use of biofuels in transport as required by this Directive. Belgium promotes the use through a reduction of special excise duties for biofuels and diesel blends, whilst Italy and Poland apply tax and excise duty rebates.
Motor vehicles and other machinery	2004/3/EC	With respect to reducing CO2 emissions from motor vehicles and other machinery, some countries (Ireland and Portugal) report on legislation transposing EU Directives on CO2 emissions and fuel consumption of vehicles whilst others have measures to encourage the purchase of environmentally friendly cars.
Promotion of renewable and energy efficiency	2001/77/EC, 2004/8/EC	Legislation does not directly transpose EU law, and diversity of measures have been employed, including tax deductions (Belgium), feed-in tariffs (Spain) or promotion of micro-generation (UK).
Taxation of energy sources and GHG emissions	2003/92/EC	Only four countries have national legislation on taxation of energy sources and GHG emissions
Energy standards for consumer products	2005/32/EC	Only three national parliaments mentioned legislation on energy standards for consumer products (Austria, Belgium and Slovenia).
Carbon capture and storage (CCS)		Only two countries mention these initiatives as demonstration projects funded with government subsidies (UK) and a government requirement to get permissions to operate a cogeneration plant (Norway).
Funding instruments		Funding is available for several activities: climate research (Austria, Sweden), Research and development of environmental technologies and climate communication programmes (Finland), the acquisition of Kyoto units (Ireland), sustainable mobility projects (Austria, Italy), energy saving and energy efficiency (Sweden)
Emissions trading	Regulation 2216/2004/EC7	All countries mention a substantive amount of legislation or transposing EU law on emissions trading. Some countries refer to legislation on national register systems (Belgium, Netherlands, Spain). Other countries mention legislation transposing or implementing Directive 2003/87/EC or Directive 2004/101/EC8 on a scheme for

	greenhouse gas emission allowance trading within the EU (Czech Republic, Finland, Germany, Italy, Netherlands, Poland, Portugal, Romania, Spain).
Emissions trading-national allocation plans	Belgium, Cyprus, Germany, Italy, Luxembourg, Slovenia, Spain, Portugal mention their NAPs for the period 2008-2012. Some countries also mention their NAPs for the period 2005-2007.
Climate change related strategies, programmes and action plans	Some countries refer to strategies, action plans and programmes which aim to reduce GHG emissions in the period 2008-2012 in accordance with the Kyoto Protocol targets (Finland, Germany, Ireland, Italy, Lithuania, Romania, Slovenia and Portugal). Other countries have longer term targets.
Transport related strategies, programmes and action plans	Some countries report on programmes, plans and resolutions specifically focussed on transport (the Netherlands, Slovakian republic, Romania).

Source: (Geeraerts et al. 2007)

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Further Details on case studies

1. Bergen, Norway

1.1. Introduction

Bergen is the second largest city in Norway with approximately 250,000 inhabitants. The city region consists of 14 municipalities with about 360,000 inhabitants. Bergen city is situated at the West coast of Norway, and is the capital of Hordaland County. It is a city in close proximity to the sea and the mountains, with large quantities of precipitation.

The case study will first focus on relevant vulnerability dimensions (cf. action 2.1) for Bergen related to sea level rise, flooding, wind, precipitation and extreme weather. Secondly, there will be a statistical mapping of selected sectors which may be affected by climate change. The mapping will be based on regional and local statistical sectoral analyses with data on LAU 2 level but it will also draw on an ongoing scenario project for Bergen which is focusing on climate impacts for the following industries: marine industries, maritime sector, tourism, energy and energy-intensive industries. Thirdly, the case study will also look into mitigation and adaptation measures taken on local/regional level in order to see what plans have been adapted and what actions have been taken.

This paper presents first the preliminary vulnerability assessment focusing on the main impacts of climate change in the Bergen region; the most important exposure and sensitivity indicators. Secondly, it gives a draft outline for a modified cost-benefit analysis (CBA) in Bergen.

1.2. Vulnerability assessment

The main impacts of climate change in the Bergen region are related to coastal flooding and flooding from rivers, and to land slide due to heavy precipitation. Important exposure indicators for the Bergen region are related to increase in mean temperature; increase in precipitation, particularly in winter and autumn; a strong increase in days with heavy rainfall and to sea level rise. Significant sensitivity indicators for the region are related to impacts on infrastructure, sewage systems, transport and build environments and settlements (physical sensitivity), cultural heritages such as Bryggen which is on the UNESCO World Heritage List (cultural sensitivity). The large share of coastal population and residents endangered by river flooding may also put people in danger (social sensitivity). Strong awareness of climate change impacts, several adaptation measures already implemented and plans for future measures, may on the other hand indicate that the adaptive capacity is strong in the Bergen region (institutional sensitivity). The following part of this section presents regional climate scenarios on temperature, precipitation and sea level rise for Western Norway and the Bergen region based on the report *Climate in Norway 2100* (Norsk klimasenter 2009).

1.3. Temperature

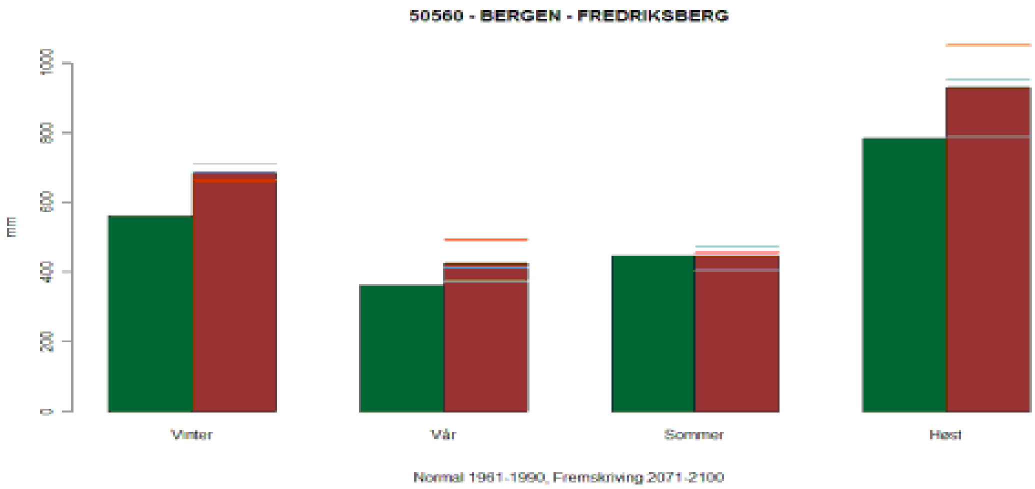
The temperature will increase in all Norwegian regions and in all seasons towards 2100. The annual mean temperature is estimated to rise with 2.3 to 4.6 °C within 2100, whereas the figures for Western Norway are 1, 9 and 4, 2. There will be a strong increase in the annual mean temperature in Western Norway from the late 1990s to 2100, and the increase is significantly bigger in the winter (M = 3.8) than in the summer (M = 2.3). All projections in the scenario show that the weather will be warmer, and that in the winter time the temperature will increase from close to zero to 4-5 °C. This implies amongst other that the agricultural growth season will be significantly extended with 1-3 months towards 2100.

1.4. Precipitation

Precipitation will increase in all parts of Norway towards the end of the century. Annual mean precipitation in winter months may increase with more than 40 percent in parts of East-, South and Western Norway in this period. The increase in days with heavy rainfall will be particularly strong in

Western Norway where Bergen is situated. Having in mind that this region already has large amounts of precipitation, annual precipitation reaches up to 5000 mm in some areas of Bergen city, and a doubling of days with heavy rainfall will increase the vulnerability related to river flooding and landslide.

Figure 1: Annual mean precipitation in Bergen 2071 - 2100



1.5. Sea level rise

During the 21st century the sea level is expected to rise with approximately 70 cm in Southern and western Norway. Figure 9 shows upper and lower level for sea level rise and storm surge for the five largest cities in Norway in 2050 and 2100 respectively. Sea level rise is estimated to be largest in Bergen and Stavanger, both situated on the west coast of Norway. In addition to the sea level rise which is estimated to increase with 75 cm, the storm surge may increase up to 221-276 cm in 2100. This will have significant damaging impacts on the city's infrastructure, transport system and tunnels, buildings and sewage system if proper adaptation measures are not implemented in due time.

Table 1: Upper and lower level of sea level rise and storm surge in the five largest cities in Norway

	2050				2100			
	Havstigning (cm)		Stormflo (cm) Relativt NN1954		Havstigning (cm)		Stormflo (cm) Relativt NN1954	
	Min.	Maks.	Min.	Maks.	Min.	Maks.	Min.	Maks.
Tromsø	10	32	229	251	43	98	267	322
Trondheim	–1	21	246	268	22	77	274	329
Bergen	15	37	178	200	53	108	221	276
Stavanger	17	39	143	165	58	113	189	244
Oslo	–1	21	189	211	21	76	216	271

(Havstigning = Sea level rise, stormflo = storm surge)

1.6. Cost benefit analysis for Bergen

The municipality of Bergen has already analysed some possible adaptation measures. The measures range from drastic protection of the whole metropolitan area by building outer barriers to a simple sheltering of limited areas. The costs of the adaptation measures have also been estimated, but the estimates contain only investment costs, not maintenance costs. The cost of building outer barriers are estimated 30 billions NOK. The costs of building three inner barriers are estimated to be slightly more than 1 billion NOK. The spunt solution for the flood prone area of Bryggen is estimated to cost less than 50 million NOK. No benefit assessments have been done in monetary terms. But, some qualitative assessments have been done like “the benefits are estimated to be small” or “the benefits are of great importance”, cf. table 2.

Table 2: Cost assessment and consequences of adaptation measures

Measures	Consequences	Costs NOK 2008
Outer barrier	Large environmental and economic consequences	> 30 Billion
Inner barrier Vågen (1)	Limited benefits	500 Million
Inner barrier Damsgårdssundet (2)	Limited benefits	500 Million
Inner barrier Strømmen (3)	Large benefits	< 30 Million
Spunt solution The old German Kay	Ground water control and protection of water front towards storm surge	< 50 million
Protection of selected areas and buildings	Flexibel solution. Secure vulnerable buildings and areas against SLR and storm surge	< 100 000 per meter

The benefits of adaptation measures can be set to equal the reduced damages caused by the measures. The aggregated costs of extreme natural events in the area can to some degree be measured by the expenses of the Norwegian Natural Damage Fund. But, the fund does not cover "normal" damages. Benefits can also to a certain extent be measured as the reduction of property values caused by flooding or the insurance value of the building, but it is unclear whether the risk of storm surges has been taken into account in the sale prices/insurance values of the buildings already. Cultural heritage is an important benefit that is even more difficult to measure in monetary terms. A problem of assessing costs of infrastructure is that some infrastructure will replaced irrespective of any climate change.

The Bergen case study will concentrate on the spunt solution of Bryggen, an area where damages can be expected in near future. We will systematically list the benefits of reduced damages, but we will not be able to put strict monetary values on all benefits. Our analysis, therefore, must be regarded as a modified CBA. The most important damages in the case of Bryggen are related to the building structure. But we do not know how well this is captured in the insurance value. The cultural heritage of Bryggen is also of value not only to Bergen, but for the whole country. In addition to the damage costs of the building structure we might also have some opportunity costs due to reduced tourism if the cultural heritage is damaged.

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2. Coastal Aquifers

2.1. Introduction

The low-lying coast area aquifers have specific threats caused by the climate change. The location on the seashore makes them sensitive for all changes in sea water level. In worst case the contamination of salt-water intrusion may happen and the aquifers in the vicinity of the sea could be destroyed. The threats concerning shallow groundwater aquifers or water supply infrastructure are serious because water supply is one of the most important requirements for living in a society.

The threats and risks to groundwater quality and quantity, caused by climate change, will be identified in groundwater case study of the ESPON Climate project. The specific risks and threats for a seashore aquifer are changes in present sea water level, contamination of salt-water intrusion, and in addition future sea level rise and changes in precipitation, temperature and evaporation caused by climate change.

The shallow sand and gravel aquifers in low-lying coast areas are most sensitive for the changes in sea water level. The level of groundwater table in aquifers bordered by sea is reflecting the changes in the sea water level.

The groundwater case study began with work in different sand and gravel aquifers on the sea shore of the Baltic Sea in South Finland. The aquifers are small in size in general in Finland and in one NUTS 3 area there can be many small aquifers. The chosen NUTS 3 areas in coast area of South Finland are two: Uusimaa and Itä-Uusimaa.

After completed the work in Finland the approach and method will be adapted to the selected study areas in Europe.

2.2. Vulnerability assessment

2.2.1. Main effect of climate change on case study region

The main effect of climate change on groundwater is changes in groundwater level in coastal aquifers. Both, the rise or fall in level of groundwater tables may affect the water supply in the area.

The methodology of the ESPON Climate project was tested in different aquifers in coastal areas of the Baltic Sea in South Finland.

Data was collected for precipitation, air temperature, sea water level, river water level, groundwater level (in tubes and observation wells), groundwater yield of the aquifers, pumping rates from the production wells, main use of the water (drinking or irrigation water), amount of the water consumers, a forecast for the pumping, main land use of the catchment (aquifer), secondary land use of the catchment (aquifer) and land use in the vicinity of the aquifer (if remarkable), and especially the location of the aquifer concerning the present sea water level (above 5 m contour). Back up plans for water supply in future has been collected from municipalities if available.

2.2.2. Exposure

The nine regional exposure indicators chosen for the ESPON Climate project were discussed and tested for the groundwater case study areas. Not all of exposure indicators were relevant or important in the climate conditions of Northern Europe. The result was that five of those indicators were suitable for the groundwater case study in Finland. Those five indicators were: 1) change in annual mean temperature, 2) changes in annual mean number of frost days, 3) changes in annual mean number of summer days, 4) changes in annual mean precipitation in winter months and 5) changes in annual mean evaporation.

The exposure indicators for groundwater in the other study areas in other parts of Europe will definitely be different and the discussion and testing will be done one by one for each chosen study area.

2.2.3. Sensitivity

The implications of long-term and rapid onset sensitivity dimensions for groundwater study case were discussed, but the approach was not yet chosen.

2.2.4. Impacts

As mentioned above, change in groundwater tables may severely affect drinking or irrigation water supply. A pilot project in Hanko found out that sea level changes have a direct affect on shallow groundwater tables after a short time delay (Backman et al. 2007). Changes in the groundwater table may also lead to contamination hazards, e.g. if the groundwater table rises close to the surface after prolonged or heavy rainfall events. Reduced overall precipitation leads to less groundwater recharge and consequently to a potential drying up of an aquifer. This may occur over longer periods in deeper aquifers but can also occur during a prolonged dry season in shallow aquifers. Thus, in addition to sea level changes, potential changes in rainfall patterns are also to be assessed.

2.2.5. Adaptive Capacity

The question is how strongly long term sea level changes may affect local water supply, i.e. how depended is a local community on a coastal aquifer, based on the assessment mentioned above? In some parts of Finland wells in coastal aquifers already had to be shut down due to sea water intake. Currently it is still possible to use wells located further away from the sea shore, but is this trend sustainable? How high is thus the dependence on a specific aquifer? And how high is the awareness of a local supplier on these potential impacts? Are assessments being carried out and are optional plans being discussed?

2.2.6. Vulnerability

The vulnerability is determined by several factors, including the amount of people depending on an aquifer but also the capacity of the water works to address and solve potential future impacts on the current groundwater supply. The vulnerability assessment will be further developed depending on the results of the exposure and sensitivity analysis

2.3. Strategies and policy development

Strategies and policy development will be based on the analysis of the impacts, the adaptive capacity and the overall vulnerability. The strategies and policy development will mostly likely not be valid for the entire ESPON space as most coastal aquifers differ from each other. It is also of importance if a region is depending on only one coastal aquifer or if it has several aquifers which might be used in the future. A general strategy and policy recommendation will be possible on a general basis, i.e. to timely assess the exposure and sensitivity of regions with coastal aquifers and to determine their overall vulnerability and adaptive capacity.

2.4. Future aspects specific to the groundwater case study

The future aspects of this case study are depending on the sensitivity and vulnerability analysis. Once these are completed, the guidelines for further development are handed over to the other case studies (see timetable). The other case studies will then have three months to carry out their own assessments. These assessments are to be done by local experts as a desk work. Local hydro-geological measurements or detailed modeling cannot be carried out in the scope of this project.

2.5. Discussion of validity of European-wide analyses from a regional perspective

The case study approach is well embedded in European seas, see also discussion above. The final reporting will take overall conclusions on the possibilities of studying coastal aquifers as based on case studies for the ESPON territory. The local assessments will deliver an overview on the situation in several European seas. The special value will be the determination of exposure indicators most relevant for each European sea. This will lead to consecutive sensitivity and vulnerability analysis of representative coastal groundwater aquifers, all following one methodological approach, which is not available so far.

2.6. Transferability of results to other regions

See above

2.7. Dissemination strategy

The dissemination of this case study is well embedded in the overall dissemination strategy (see updated version delivered after the ESPON Climate meeting in Espoo).

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3. Netherlands

Flooding at the European scale

Different types of flooding can be distinguished (EXCIMAP 2007). Taking flooding into account encounters a methodical problem. The framework of the project is vertically oriented (no spatial interrelations) whereas even pluvial flooding, but especially river flooding depends largely on horizontal processes. Furthermore, sea level rise is not (yet) a climate stimulus as a result of which the effect of storm surges is hard to assess. The most obvious way of tackling both problems is, similar actually to the use of RCM output, the use of potential flood plane estimates. On the European scale two essentially different data sources are available with respect to river flooding:

1. the event based map compiled within the ESPON hazard framework (ESPON);
2. the model based map of the JRC (Feyen 2006), also used in the PESETA project.

Also available from JRC is a coastal flooding map based on the DIVA tool developed within the framework of the DINAS-COAST project.

A small project was carried out to identify the differences between the JRC method and a more sophisticated Dutch approach (Mens 2009). The main conclusions of this study:

1. JRC uses a catchment map to derive water courses, but this is not suitable for flat areas and cannot deal with bifurcations (branching rivers).

2. Even if a better catchment map were used, the method to arrive at flood extent and water depths is not suitable for low-lying areas with flood defenses in place. The GISbased models used by JRC cause the water depths and flood extent to be grossly overestimated. Along the coast, the tides will limit the amount of water flowing in. Along rivers, the amount of water is limited by the volume of the discharge wave.
3. JRC has not taken into account existing flood defenses or secondary embankments and obstacles. This makes a hazard map for 1:100 per year floods at least irrelevant for the Netherlands, because the majority of the country is protected against more extreme flood events.

Case study the Netherlands

The Dutch case study will be focused on two topics:

1. flooding (main rivers, large lakes and sea)
2. fresh water availability

The case study will be elaborated using the framework of the project, including the indicators used within this framework.

Relevant climate stimuli:
storm surges – no relevant indicator
sea level rise – temperature
river flooding – winter precipitation, number of days with heavy rainfall
fresh water availability – evaporation, summer precipitation

Vulnerability indicators for flooding:

1. physical: settlement and infrastructure prone to floods (river and storm surges)
2. environmental: none
3. cultural: cultural monuments, UNESCO world heritage sites, museums
4. social: population prone to floods
5. economical: none

Vulnerability indicators for water availability:

1. physical: settlement and infrastructure prone to floods
2. environmental: especially sensitive/protected natural areas, ecoregions especially sensitive to climate change
3. cultural: cultural landscapes
4. social: none
5. economical: agriculture, energy

Output of two recent studies on climate proofing the Netherlands (Ligtvoet 2009), (Ligtvoet 2009)will be used to validate the framework applied to the Netherlands

Sources

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EXCIMAP (2007): Handbook for good practices for floodmapping in Europe, Copenhagen: EEA.

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Ligtvoet, W., Knoop, J.M.; Strengers, B.; Bouwman, A.F. (2009): Flood protection in the Netherlands: framing long-term challenges and options for a climate-resilient delta. Bilthoven, PBL.

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4. North-Rhine Westphalia, Germany

With around 18 million residents North-Rhine Westphalia (NRW) is the most populous state of Germany and includes Europe´s largest conurbation (the Ruhr district). The state comprises 396 municipalities (LAU2, see Figure 1) ranging from rural to urban characteristics, with different climate conditions.

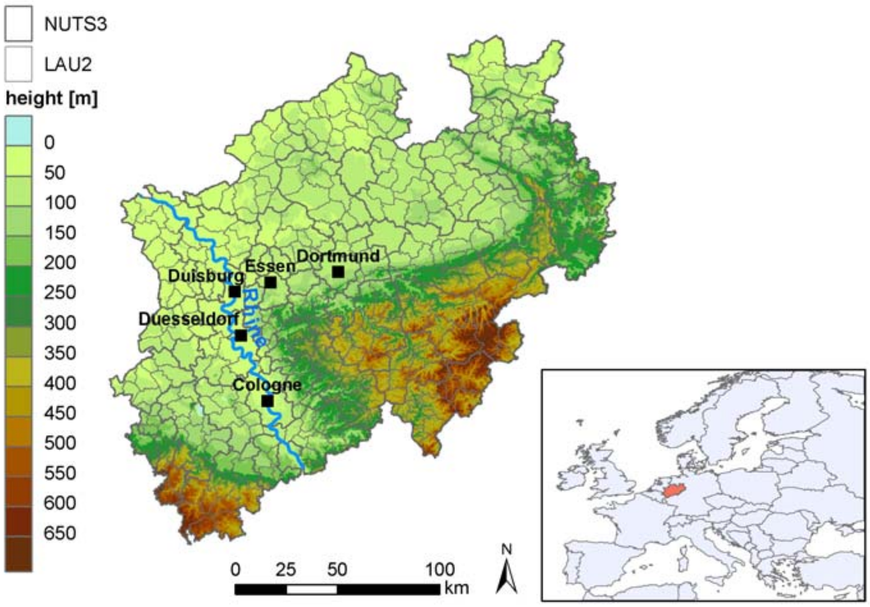

Figure 1: Topography and administrative units (NUTS3 and LAU2) in North Rhine-Westfalia and its location within Europe (red inlet)

While in summer it can become very hot in the Rhine-Ruhr Basin, the temperature in the highlands and mountainous regions is more moderate (Sauerland, Eifel mountains). The latter are recreational regions for the densely populated Rhine-Ruhr area. Climate scenarios imply that temperature increase, seasonality and the amount of precipitation change, as well as a generally decrease of river run-off in summer.

NRW also account for around one quarter of the German GDP. Functioning of the economy needs a sufficient infrastructure and depends on energy production. While these branches can be affected by decreasing river run-off (river water for cooling), freezing rain or heatwaves, other sectors are risk prone to increasing temperatures or storm events, like the forest sector or the skiing areas situated in the low mountain range. Thus, climate change thus might have strong impacts in different regions of this state.

For this case study, the developed European-wide vulnerability system will be applied and, where possible, adapted to the characteristics of this region. Thereby the sensitivity analysis will focus on the environmental, economic, social and physical dimensions, as these are expected to be effected under the projected climatic changes.
Nevertheless, links between vulnerability components as (as a core of any vulnerability concept) are likely to be lost with this method. Moreover, definition of thresholds to the corresponding exposure/impact groups may result difficult and the aggregation of components could lead to a loss of information and transparency. A systemic approach (in contrast to the proposed five

dimensions) has proved to convey best the information in this case-study area, since this is normally in the operational focus of decision makers.
Thus, in addition to the proposed European-wide vulnerability system, a vulnerability analysis of exemplarily systems, where information about process links already exist, will be carried out. Further, it is intended to compare some of the obtained results from the systemic approach with results based on other climate models, e.g. the regional statistical model STAR II (Werner et al. 1997, Orlowsky 2007)
.
Moreover, it is intended to develop indicators of climate change impact on a spatial scale of LAU2 (municipalities, see figure 1), thus providing more detailed spatial information than on the European level.
As an example of a systemic approach, the vulnerability of humans towards heat waves will be discussed. The exposure is characterized by an increase in heat wave days projected by the regional climate models STARII and CCLM. The sensitivity is described by the urbanity of the region, expressing the urban heat island potential as a crucial factor for intensifying heat waves in urban areas, and by the share of population aged 65 years or older as a particular sensitive group towards heat events.

In this sense, the case study NRW can help to validate and complement the methodology and results of the European-wide vulnerability analysis. An application of a cost benefit analysis would fall beyond the scope of this case study. Nevertheless, exemplary cost calculations of climate related events could be discussed from literature sources.

Sources

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5. Alpine Space

The European Alps comprise an area of 190,000 square kilometres in the centre of Europe and are shared by eight countries. The Alps are characterized by mostly rural areas, but many of its 13 million inhabitants live in the densely populated river valleys. These and several Metropolitan Growth Areas in the surrounding lowlands need a transnational strategy how to foster climate change mitigation and adaptation.

Within the last 150 years climate change has already led to a significant increase of temperature of around + 2 °C, more than twice the rate of average warming of the Northern hemisphere. This has lead to a retreat of glaciers, change in seasonal mean temperature as well as precipitation patterns and a decline of snow cover (EEA 2009).

Climate change scenarios based on Regional Climate Models (RCM) project continuously rising temperatures for the Alps up until the end of the 21st century (between + 2.6 °C and + 3.9 °C), with an accelerated increase in the second half of the century (EEA 2009, CLISP 2009). As in the past, the Alps will be exposed to a stronger warming than the rest of Europe. Temperature will rise particularly in the high mountains (> 1 500 m) with a 4.2 °C increase.

Projected changes in precipitation are moderate in terms of the yearly total, but show significant changes within the seasons. The Scenarios expect a decrease in summer precipitation and, in most regions, an increase in spring and winter precipitation; except in the Southern Alps, here only winter shows increase in precipitation

These further increases of temperatures and higher variability of precipitation are expected to result in changes of glaciers, permafrost zones, water scarcity in summers and reduced snow reliability in winter months. The occurrence of alpine hazards (e.g. avalanches, land slides) is also forecasted to increase significantly.

Tourism in the Alpine Region is one of the economic sectors most affected by these climate change stimuli. After the Mediterranean Region the Alps are the second most favoured holiday destination in Europe. With 60 million overnight guests tourism is in most rural and alpine regions in the European Alps the most important economic sector.

In order to understand the impacts of the different climatic stimuli the tourism sector needs to be differentiated in summer and winter tourism as well as the touristic zone (city tourism, rural tourism and alpine tourism). The most important impact of the different climatic stimuli is a change of the attractiveness. Generally speaking previous studies expect an increase of attractiveness for summer tourism due to more summer days and a longer season; and a decrease of attractiveness for winter tourism due to a decrease in snow cover, shorter season and an increasing risk of natural hazards (OECD 2007; Steiger, Mayer 2008). The cause-effect relations between climatic stimuli and regional and seasonal sensitivity of the tourism sectors resulting in specific potential impacts are going to be investigated in detail in the main phase of the case study Alpine Space. One result will be detailed and zone specific climate change impact chains for summer and winter tourism.

Based on this analysis possible adaptation strategies and measures can be related to the potential impacts of climate change in the tourism sector. Current studies discuss a broad range of adaptation strategies, varying from short-term reactions technical adaptation (artificial snow production) and economic risk reduction through organizational measures to long-term adaptation strategies like diversification of touristical offers (especially in summer tourism), spatial expansion and concentration of winter tourism in high altitudes or retreat from touristic sites which are not cost efficient (Müller, Weber 2008; Hoffmann et. Al 2009; Steiger, Mayer 2008).

The Alpine Space case study will follow the overall methodological framework of the ESPON Climate project, detailing and cross-checking findings of the pan-European exposure, sensitivity and adaptation analyses. Subsequently the case study will focus especially on economic sensitivity and investigate current and potential proactive and long-term adaptation options within the tourism sector.

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6. Tisza River Basin

6.1. General description of the area

The Tisza River Basin is the largest sub-basin in the Danube River Basin, covering 157 186 km² (19.5% of the Danube Basin), it is home to approximately 14 million people.

Figure 1: *Tisza River basin in Europe*

The Tisza River Basin can be divided into two main parts:

- the mountainous Upper Tisza and the tributaries in Ukraine, Romania and the eastern part of Slovakia and
- the lowland parts mainly in Hungary and Serbia surrounded by the East-Slovak Plain, the Transcarpathian lowland (Ukraine), and the plains on the western fringes of Romania.

Countries of the river basin

Country	Share of the countries from the area of the Tisza River Basin (km²)	Percentage share of the countries from Tisza River Basin area (%)	Percentage of Tisza River Basin area of the whole national territory of each country (%)
Hungary	46,213	29.4	49.7
Romania	72,620	46.2	30.5
Serbia	10,374	6.6	11.7
Slovakia	15,247	9.7	31.1
Ukraine	12,732	8.1	2.1

ICPDR

Historical background

Landscape features before the regulation

- Until the eighteenth century land use had conformed to the rhythm of flooding, which meant that water was spread out on the widest possible territory, filled up fish lakes, irrigated meadows and pastures with trees, orchards. In the same time destructive floods was avoided.

- During the eighteenth century there was a major decline in forest territory on the hilly areas, bordering the Great Hungarian Plain, while the cultivated areas underwent dynamic growth due to the rise in population and the wheat boom. The growth of the plough land was soon limitted more and more by flood danger.

During the second half of the 19th century, extensive measures of river regulation and flood control were undertaken on the river. As a result of these works, the river's total length was shortened by approximately 30% and it is today 966 km. The flood area and its wetland habitat decreased to one tenth of the previous territory.
The case study area is a river basin of highly sensitive location from climatic aspects. This territory is most threatened in Europe in terms of the decrease of precipitation, and of warming, and therefore the climate here will become particularly dry. The temporal distribution of both warming and precipitation will change too. Dry periods will be followed by sudden, heavy rains, and the floods will be devastating. According to the most recent scientific results, extreme (and more severe) meteorological and hydrological events (such as flash floods, heavy precipitation, droughts etc.) will significantly increase by the middle of this century in the case study area.
In the pursuance of the elaboration of the vulnerability assay, the main topics are the following:

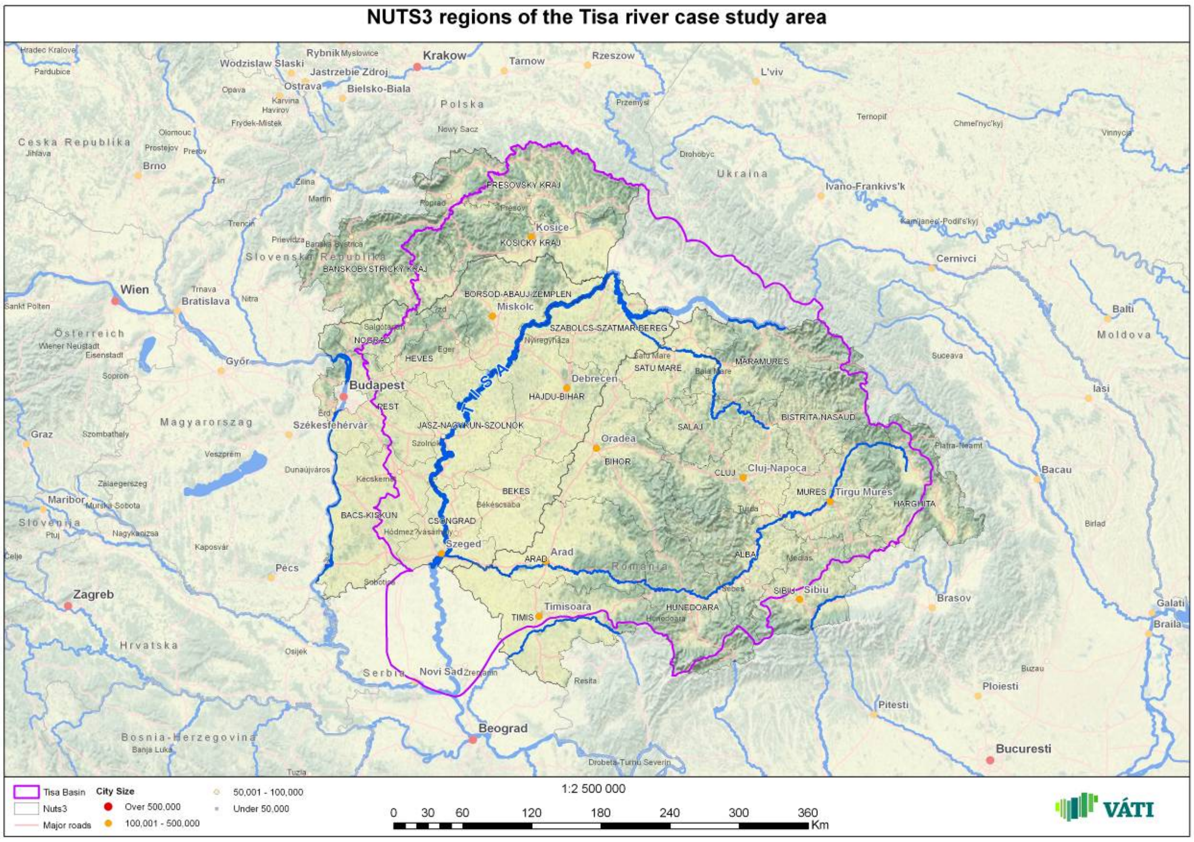
- risk in the built environment (caused by flood)
- risk in agriculture and rural development (caused by drought),
- increasing rate of erosion,
- decreasing of biodiversity.

In the study area the assessment of vulnerability is also based on the comprehensive analysis of sensitivity, exposure and adaptive capacity. The most important indicators during the assay of the exposure is the change of precipitation and temperature, respectively increase of flow. The indicators of sensitivity are the relevant environmental, economical, and sociological variables. Regarding adaptive capacity, the regulation and the change of land use, respectively the alternative strategies of the food area protection has significant importance.

Delimitation of the case study area

The institutions of three countries (Hungary, Romania, Slovakia) elaborate in cooperation the Case Study on the Tisza River of the ESPON Climate Change Project. The smallest area units of the analysis will be NUTS 3 regions. The catchment area of river Tisza extends to 10 NUTS regions in Hungary, 13 in Romania and 3 in Slovakia. Therefore the Tisza River case study area comprises 28 NUTS 3 regions in Hungary, Romania and Slovakia respectively.

Figure 2: *NUT3 regions of the Tisza river case study area*



NUTS 3 regions (counties) in Hungary: Bács-Kiskun, Békés, Borsod-Abaú-Zemplén, Csongárd, Hajdú-Bihar, Heves, Jász-Nagykun-Szolnok, Nógrád, Pest és Szabolcs-Szatmár-Bereg.
NUTS3 regions (counties) in Romania: Alba, Arad, Bihor, Bistrita-Nasaud, Cluj, Harghita, Hunedoara, Maramures, Mures, Salaj, Satu-Mare, Sibiu and Timis.
NUTS3 regions (kraj) in the Slovak Republic: Banskobystricky kraj, Kosicky kraj and Presovsky kraj.

6.2. Territorial characteristics

6.2.1. 2.2 Settlement pattern

In the catchment area of river Tisza there are two cities only (Cluj and Timisoara) with over 300 thousand population. Five cities are of the range of 100,000 – 300,00 population (Debrecen, Szeged, Miskolc, Kosice, Oradea). The municipalities of 10,000 – 100,000 population are for the most part, on the Great Plain of Hungary. The majority of the municipalities of the Tisza river catchment area have less than 10,000 inhabitants. There is a large number of very small communities with less that 1000 population. The majority of these are in the hilly and mountainous areas.

6.2.2. Land Use

The geographical differences are determinant for the evolved land-use. In the hilly and mountainous areas the forests, on the plains arable land is the dominant land use. The forest in total cover 4,312 thousand hectares, that is 27 % of the catchment area. On the high mountains coniferous woods, on the mountains of medium height deciduous trees are dominant. The majority of grasslands (pastures and meadows) are also on mountains and hills, and cover large lowland areas too (e.g. Hortobágy in Hungary). The plains are predominantly plough lands. Arable land covers 35 % of the catchment area, the greatest part is in Hungary (the Great Hungarian Plain)

6.2.3. Social conditions

Hungary

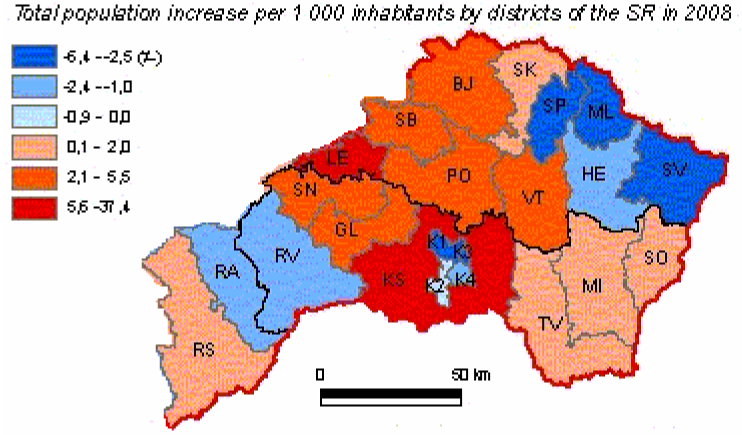
The Tisza/Tisza river basin situated in Hungary covers 42% of the country's territory and the proportion of the population was the same in 2005. The planning area encompasses 1,187 settlements, 86 micro-regions (NUTS4), 10 counties (NUTS3) and 4 regions (NUTS2).
The population of the Tisza/Tisza river basin numbered 4.3 million in 2005. Twenty-three percent of the inhabitants live in eight towns with over 50 thousand people (1% of the settlements), whereas 1.5 % of the population of the region lives in small scattered villages.
Population density is higher in the surroundings of the capital city, around the county seats, cities and large towns, whereas it is lower in rural towns and villages of Alföld (Great Plain) dominated by large agricultural fields and in scarcely populated rural regions without urban centres.
Similarly to the national trends, the population of the region has been declining continuously since 1980 but with different trends hidden behind the average. Growing population characterises the urbanised micro-regions of Pest county and Budapest and a few North Great Plain micro-regions with youthful age structure. There is significant population erosion in several South Great Plain and border micro-regions that are hit by ageing and outward migration.
Beyond natural trends, demographic developments are largely influenced by the economic position of the regions. In respect of several factors, the bulk of the planning area went on a downward path along the dividing lines of the economic structure evolving after the change of the political system with long-term effects.
Employment in 70% of the micro-regions is falling behind the national rate though this latter is also low. The ratio of agricultural employees exceeded the national average in 44% of the micro-regions, and the ratio of industrial employees in 40% of them.
Unemployment rate has been above the national average since 1993. While in 1993 the difference in the rates of unemployment between micro-regions with the highest and lowest number of employees was threefold, by 2005 it grew fivefold despite a reduction achieved in most of the micro-regions. This will be a long-lasting problem, because the proportion of people with low educational level and without marketable qualifications is high in these regions and the widespread survival strategy is limited to acquiring the status of early retirement and disability pension.

Slovak Republic

The Tisza/Tisza river basin situated in Slovakia covers 31.09 % of the country's territory and the proportion of the population was 27.26% in 2004. The planning area encompasses 1,276 settlements, 23 districts (NUTS4), 3 NUTS3 regions and 2 NUTS2 regions.
The population of the Tisza/Tisza river basin numbered 1.468 million in 2004. Twenty-two percent of the inhabitants live in 2 towns with over 50 thousand people (0.1% of the settlements). The rural population dominates over urban population (79% to 21%). Population density is 162 inhabitants / km^2.
Population density is higher in the surroundings of the centre of regions (Košice, Prešov) and around the regional seats, whereas it is lower in villages of East-Carpathian Mountains of north-east part of the area (districts Snina, Medzilaborce) and Central-Carpathian Mountains of middle Slovakia (districts Revúca, Rožňava, Revúca, Rimavská Sobota). This mountainous area of Tisza river basin is settled by small villages, area is dominated by large forest area.

The population of region is growing, but in comparison with former decades (60^{th}, 70^{th}, 80^{th} years of 20^{th} century) growth of population is considerably slower, approaching stagnation. Population is growing most evidently in urbanized area (Košice, Prešov). This is caused by immigration from rural areas of north and east districts. The worst situation is in rural areas of east and mountainous parts. Decreasing of population number is caused by ageing and emigration to cities and abroad.

Figure 3: Population development



(Source: Slovak Statistical Office)

Demographic development is influenced by the economic position of the region, which is combined with long-term effects (decrease of fertility rate, lower percentage of employment in agriculture). This part of Slovak Republic is the most under-developed, with the very high unemployment ratio. In the frame of Tisza river basin (Slovak part), unemployment rate is lowest in big cities (Košice and Prešov), high unemployment rate characterizes districts of easternmost districts and south-west part of area (mountainous regions - handicapped by destruction of metallurgical industry, which was determining for economical development of these micro-regions for many years). Similarly structural problems of agricultural sector have caused economical problems of south-eastern part of studied area – lowlands of districts Trebišov, Michalovce and Sobrance (geomorfologically very similar to north-eastern part of Hungary).

6.2.4. Economic conditions

Agriculture

During the last 15 – 20 years there has been a marked decline of agriculture in the Tisza catchment area. There was a sharp decrease in agricultural employment and in the share of agriculture in national economic output. Nevertheless, both land cultivation and animal husbandry are still significant economic activities, especially in comparison with the European situation. The plain areas are dominated by arable functions. The main outputs are cereal (autumn wheat, corn, autumn and spring barley, rye) and there has been a growth in oilseed (rape, sunflower) plants. In areas of appropriate soil conditions large estates are dominant with intensive agricultural technologies. The survival of traditional landscape farming is characteristic in areas of poorer soil conditions and in areas where the farming conditions vary in a mosaic pattern.

Forestry

The percentage share of forestry in the economic structure has declined, but its importance in the mountainous and hilly parts of the catchment area still prevails. More than half (53 %) of woodland is in the hilly and mountainous areas of Romania. An important challenge of forest management is felling and the decay of forests, involving erosion after logging.

Tourism

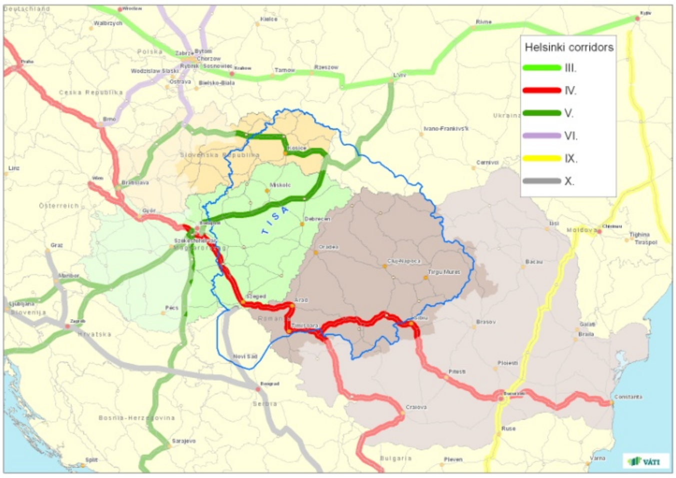
The region is rich in terms of Tourist assets. The hills and mountains offer excellent conditions for winter sports (skiing, hiking) and for eco-tourism and for the demonstration of natural values. The lowland areas are suitable for soft tourism to the attraction of natural beauties, natural rarities as well as traditional landscape farming activities, whereas the urban areas offer ample possibilities for cultural tourism. The underdevelopment of tourist infrastructure is an obstacle of the utilization of the high tourist potential.

6.2.5. Transportation system

The transnational transport connections of the Tisza Catchment Area are based on the so called Helsinki corridors (specified in 1997), which are the extensions of the EU transport system to Eastern Europe. The catchment area is crossed by corridor IV connecting Germany with the Black Sea and Aegean Sea through the Czech Republic, Western Slovakia, Hungary, Southern Romania, Bulgaria and Greece. This corridor is thus a connection between the north-western and south-eastern parts of the Tisza Catchment Area. Also important is corridor V connecting Northern and Eastern Europe with the Adriatic sea, and the north-eastern and south-western parts of the Tisza Catchment Area.

The Danube, corridor VII is a throughway in the Tisza Catchment Area, is outside the case study area. Although Tisza is a tributary river of the Danube, corridor VII is accessible from the greatest part of the Tisza Catchment Area by road only. There is no waterway connection between these rivers, because river Tisza does not meet the standards of international waterways.

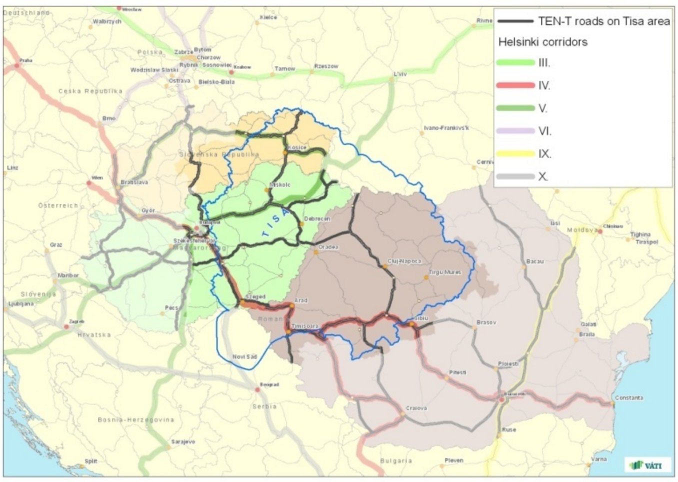
Figure 4: Helsinki corridors



The three countries of the case study area are connected to the EU TEN-T (Trans-European Network for Transport) system. Besides the corridors mentioned above the case study area is linked to the TEN-T system through the corridors connecting Eastern Poland - Presov – Kosice – Miskolc – Debrecen – Oradea – Cluj Napoca – Alba Julia and Central Poland - – Zilina – Zvolen – Budapest. Both lines are essential in Eastern Europe, because the former is a section of the corridor along the eastern border of the European Union, whereas the latter connects the east – west Helsinki corridors in north-western direction.

These transnational road links are foreseen as motorways in the future, now their majority are still ordinary highways.

Figure 5: TEN-T road network int he case study area



The railway network of the Helsinki corridors has been extended in the TEN-T system. The improvement of the parameters of the transnational railway network thus specified – development to dual track and 160km/h speed capacity – is underway.

6.3. Geographic characteristics

6.3.1. Climate and hydrology

Climate

The climate of the catchment area of the Tisza river is varied and has oceanic, Mediterranean and continental features. These characteristics greatly influence the quantity as well as the distribution of precipitation. There are large differences among the area units in terms of the quantity of precipitation. In mountainous areas the yearly average of precipitation is over 1000 mm, on lowlands this value is below 500 mm. The aridity index is high in the lowlands, and it is low in the mountains. Draught is already a serious challenge on the lowlands and has negative impact on cultivation.

Hydrology

There are two sources of River Tisza - the White and the Black Tisza - in the Northern Carpathian Mountains. The length of the river is measured from the Black Tisza. Before the large-scale river regulatory interventions the length of river Tisza was over 1,400 km. From the medieval times, on the extensive floodplains the land-use structure was adjusted to the functioning of the hydrological system (floodplain landscape management). Later on, during Turkish occupation of the 16-th – 17th centuries this type of management just as all farming activity declined, the floodplain became swampy, the previous sustainable land use declined and was given up at most places. As a result of river regulation in the 19th century, the length of river Tisza decreased by 30 %, and only small parts of the floodplain remained. For the protection of the areas released from regular floods, one of Europe's largest scale flood protection system was constructed.
The length of river Tisza is 964 km now, as a result of regulation. The first 200 km section flows in mountains, the other 760 km section is on plain. Descent in the section in the mountains is considerable: it is 1600 m on the 270 km length between the source and the issue of river Szamos. On the other 700 km long section on the plain descent is no more than 32 m. The average width of the river valley is 3 – 4 km, and this width grows to 10 km at the river delta. The width and depth of the river bed are gradually growing downwards. The river bad is 100 – 200 m wide. The depth of the water – at low ebb – ranges between 1 – 1.5 – 4-5 m, and up to 7-10 m at certain points.
The largest tributary rivers with their own partial catchment areas are Szamos, Bodrog, Sajó, Hernád,, Zagyva, Körös, Maros, Szamos. The largest canal is in Serbia connecting rivers Tisza and Danube, called the Danube – Tisza – Danube canal system.

6.3.2. Geology

The bulk of the River Tisza catchment area is made by mountains and hills belonging to the Carpathian Mountain Range. The Carpathian Mountains are divided into subsidiary units. The catchment area extends to the Eastern and North-Eastern Carpathians, the Southern Carpathians and to Apusenii, the Transylvanian Insular Mountain as well as to the inner range of North-Western Carpathians. The south-western and middle parts of the catchment area (30 % of the total) are made up by flat plain. The greatest part of the catchment area is covered by sediments (limestone in the mountains and sand and loess on the plain) and in some parts, for instance in the inner range of the Carpathian mountain, there are volcanic heights (Mátra, Hargita) too.

6.3.3. Natural assets /Biosphere

The catchment area of River Tisza is rich in natural assets. There are several large National Parks and the ratio of Natura 2000 areas is high, over 20 %. The high mountains are parts of the Alpine biographical region, the basins and hills in the Romanian section are in the Continental biographical region, the plains are parts of the Pannonian biographical region, a specific region of the Carpathian Basin.

6.4. Outlook

According to the results of the exposure analysis of the pan European space (based on the CCLM model) precipitation will decrease in summer and increase in winter month. Both, annual mean number of summer days and annual mean temperature will increase. In a consequence of these changes both frequencies and magnitude of floods and impacts of drought will increase.

The sensitivity to climate change also varies according to climatic, geographic and demographic features of the different parts of the Tisza River Basin. In the lowlands increasing drought problems will have serious consequences for agriculture. Even thought there has been a marked decline of agriculture in the Tisza catchment area, both land cultivation and animal husbandry are still significant economic activities, especially in comparison with the European situation. The plain areas are dominated by arable functions and the number of individual farmers is notable.

In the mountainous parts climate change will especially impact on valuable protected areas. Due to climate change it is expected that the habitats will alter and biodiversity will decrease.

On the other hand in the mountainous areas the increasing erosion also will cause negative impact especially on soils.

In the whole territory of the river basin the risk in the built environment (settlements, technical infrastructure) and in agriculture (arable land) will rise due to increasing floods.

Based on a comprehensive assessment of exposure, sensitivity and adaptive capacity in the Tisza River Basin, the case study will focus on river-related (floods) and drought impacts, followed by an analysis or exploration of adaptation strategies suitable for this multi-national river system.

Regarding adaptation, the regulation and the change of land use, respectively the alternative strategies of the flood area protection has significant importance.

Sources

ICPDR (2007): Preliminary Analysis of the Tisza River Basin

7. Mediterranean Spain

During the period of reference, we have worked on two topics: first, a general assessment of the importance of tourism for the Spanish economy, and the likely impacts of Climate Change on this sector, and second, an assessment of future precipitation patterns under conditions of climate change in the study areas. This assessment is basic to develop possible future scenarios of water availability for the tourist sector of the study area.

7.1. The Spanish tourist industry and climate change

Despite the occasional impacts of global economic downturns, world tourism is expected to increase in the next decade. Estimates by the World Tourist organization foresee 1500 million trips in 2020 a growing part of which will be constituted by Chinese, Indian, Russian, and Brazilian middle classes. Most of this growth will take place in the Asian markets, although Europe as a continent will continue to be the most important tourist destination, with the Mediterranean (some 345 million tourists expected for 2020) as the leading market. New destinations and new tourist products will appear and the elderly will form a growing part of the tourist market. These trends need to be taken into account when planning new tourist areas.

As far as Spain is concerned, tourism raised more than 100 billion euro in 2006 (11 per cent of national GNP) and employed some 12.5 per cent of the active population. Tourism is the single most important economic activity of this country although the sector is currently undergoing important processes of restructuring that affect mostly the mass market of “sun and beach” tourism. Moreover, there is an increase in residential tourism (linked to migratory flows from Northern, Central and Western Europe), a decrease in the average spending per tourist, and a decrease in the average length of stay per tourist as well. The internet and low cost air travel is also contributing to alter predominant patterns especially in what concerns a certain decrease in tour operator activity. Changes in work and school schedules leading towards more fragmented vacation periods may also be significant in the future. Finally competing destinations in the Mediterranean and elsewhere are also adding pressures to the Spanish mass tourist market.

Regarding climate change, some trends can be foreseen according to the PESETA project and other studies: first, a shift in seasonality patterns: the summer season will likely concentrate less tourists while the late spring and the early autumn seasons may attract more visitors to the Spanish coastal resorts. Furthermore and due to the presumably worse conditions of comfortability in competing Mediterranean destinations (i.e. the East or Northern Africa), Spanish destinations could gain a certain competitive edge with respect to these destinations, although they would probably fare worse in front of Central and Western European destinations. Finally, the increase in extreme events may also cause important problems for Spanish coastal areas: besides the effects of increasing storm episodes on beach erosion, more droughts may also bring problems for water supply and water quality of tourist destinations.

7.2. General future precipitation patterns in Mediterranean Spain

The Iberian Peninsula is above all characterized by a high climatic diversity and variability, and consequently by high inter-annual variations of precipitation. The evolution of the average temperature since the mid 19th century indicates a rising trend somewhat similar to that of average global temperature, although corrected by the influence of the sea in coastal locations. While IPCC reports that precipitation in the study area will decrease substantially in summer, regional models do not show a clear trend. Nevertheless, the most likely trend towards the end of the 21st century (A2 emission scenario) points towards reductions from 10-20 percent of average precipitation in Catalonia (North) to more than 30 percent in Andalusia (South) Even taking into account uncertainties and even in the low emissions scenario, the increase in water deficit is highly likely in late spring, summer and most of autumn because of the increase in temperature.

Dissemination plan

1. **Goals:** The goal of the dissemination is to make the project broadly known within Europe and beyond.
2. **Objectives:**
    1. Supporting policy development with applied sciences
    2. Contributing to the scientific discussion
3. **Users:**
    1. Policy developers on EU, regional and local level (territorial cohesion, regional development, climate change adaptation strategy development)
    2. Scientists interested in integrated climate change impact analysis
4. **Targets:**
    1. The EU Commission (mainly represented by DG Regio but also Research and DG Environment, JRC, EEA)
    2. Macro-Regional stakeholders (e.g. INTERACT, INTERREG IV secretariats, HELCOM, etc)
    3. The European Parliament
    4. Regional and local stakeholders (Regional councils, metropolitan regions, etc)
    5. International scientific organizations, e.g. Association of European Schools of Regional Planning (AESOP), EuroGeoSurveys, International Union of Geologic Sciences (IUGS), etc and related conferences
    6. Other international organizations, e.g. UN Habitat, UNEP
5. **Communication media:**
    1. Progress reports and map sets
    2. Webpage
    3. Short 1-page summaries of the project reports
    4. Peer reviewed scientific articles and book publication(s)
    5. Participation in stakeholder meetings and conferences (e.g. EU Commission, EU Parliament)
    6. Paper presentation at international conferences
    7. Seminars, workshops and lectures
6. **Main communication channels:**
    1. The prime target is regional development, i.e. the ESPON Monitoring Committee (MC) and the European Contact Points (ECP). The project intends to produce 1-page summaries of each progress report to raise awareness on the ongoing results of the project. These summaries shall be distributed to the MC's and ECP's, probably with the support of the ESPON CU to achieve greater acceptance
    2. JRC is associated to the project and will get hands of all reports. The EEA and the European Parliament belong to the interest group of the project (the project has been invited to workshops and seminars to present methodology and results)

3. The 1-page summary can be distributed to the INTERACT and all INTERREG secretariats, with support from the ESPON CU
4. Regional and local stakeholders shall be contacted by ECP's. Project partners are to setup own dissemination plans to inform local stakeholders of their respective countries
5. International scientific organizations are contacted via scientific presentations, papers, workshops, seminars and lectures (see attached list)
6. The project webpage. The URL of the webpage shall be included in every report, the 1-page summary as well as in the ppt's of project presentations

7. **The success** of the project's dissemination can be measured by:
    1. Visitors to the webpage
    2. Invitations to lectures, seminars, conferences, etc to present and discuss results
    3. Acceptance of abstracts to conferences, seminars, etc
    4. Invitation to expert groups (e.g. on special targeted analysis)
8. **Responsibilities and support**
    1. The main responsible for dissemination are Partner 2 (GTK) and the lead partner (IUNIDO). Nevertheless all partners should also strongly concentrate on disseminating the project results, not only to the scientific community but especially on national and local level.
    2. The success of the dissemination can be improved by a strong support from the ESPON CU, especially in addressing MC's and ECP's, as well as The European Commission and regional secretariats, e.g. INTERACT and INTERREG.

Glossary

Adaptation
Adjustment in natural or *human systems* in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Adaptive capacity (in relation to climate change impacts)
The ability of a system to adjust to *climate change* (including *climate variability* and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Aggregate impacts
Total *impacts* integrated across sectors and/or regions. The aggregation of impacts requires knowledge of (or assumptions about) the relative importance of impacts in different sectors and regions. Measures of aggregate impacts include, for example, the total number of people affected, or the total economic costs.

Aquifer
A stratum of permeable rock that bears water. An unconfined aquifer is recharged directly by local rainfall, rivers and lakes, and the rate of recharge will be influenced by the permeability of the overlying rocks and soils.

Baseline/reference
The baseline (or reference) is the state against which change is measured. It might be a ‘current baseline’, in which case it represents observable, present-day conditions. It might also be a ‘future baseline’, which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.

Biodiversity
The total diversity of all organisms and *ecosystems* at various spatial scales (from genes to entire *biomes*).

Capacity building
In the context of *climate change*, capacity building is developing the technical skills and institutional capabilities in developing countries and economies in transition to enable their participation in all aspects of *adaptation* to, *mitigation* of, and research on *climate change*, and in the implementation.

Carbon dioxide (CO2)
A naturally occurring gas fixed by *photosynthesis* into organic matter. A by-product of fossil fuel combustion and *biomass* burning, it is also emitted from land-use changes and other industrial processes. It is the principal *anthropogenic greenhouse gas* that affects the Earth’s radiative balance. It is the reference gas against which other greenhouse gases are measured, thus having a Global Warming Potential of 1.

Catchment
An area that collects and drains rainwater.

Climate
Climate in a narrow sense is usually defined as the ‘average weather’, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the *climate system*. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

Climate change
Climate change refers to any change in *climate* over time, whether due to natural variability or as a result of human activity. This usage differs from that in the *United Nations Framework Convention on Climate Change (UNFCCC)*, which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global *atmosphere* and which is in addition to natural climate variability observed over comparable time periods'.

Climate model
A numerical representation of the *climate system* based on the physical, chemical, and biological properties of its components, their interactions and *feedback* processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity (i.e., for any one component or combination of components a hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterisations are involved. Coupled *atmosphere*/ ocean/sea-ice *General Circulation Models* (AOGCMs) provide a comprehensive representation of the climate system. More complex models include active chemistry and biology. Climate models are applied, as a research tool, to study and simulate the climate, but also for operational purposes, including monthly, seasonal, and interannual *climate predictions*.

Climate prediction
A climate prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate in the future, e.g., at seasonal, interannual or long-term time scales. See also *climate projection* and *climate (change) scenario*.

Climate projection
The calculated response of the *climate system* to *emissions* or concentration *scenarios* of *greenhouse gases* and *aerosols*, or *radiative forcing scenarios*, often based on simulations by *climate models*. Climate projections are distinguished from *climate predictions*, in that the former critically depend on the emissions/concentration/*radiative forcing* scenario used, and therefore on highly uncertain assumptions of future socio-economic and technological development.

Climate (change) scenario
Aplausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships and assumptions of *radiative forcing*, typically constructed for explicit use as input to climate change impact models. A climate change scenario' is the difference between a climate *scenario* and the current climate.

Downscaling
A method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses.

Drought
The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.

Ecosystem
The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, *biomes* at the continental scale or small, well-circumscribed systems such as a small pond.

Ecosystem services
Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or *biodiversity* maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or *carbon sequestration*, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.

Emissions scenario
A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., *greenhouse gases*, *aerosols*), based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change) and their key relationships. In 1992, the IPCC presented a set of emissions scenarios that were used as a basis for the *climate projections* in the SecondAssessment Report. These emissions scenarios are referred to as the IS92 *scenarios*. In the IPCC Special Report on Emissions Scenarios (*SRES*) (Nakićenović et al., 2000), new emissions scenarios – the so-called SRES scenarios – were published.

Ensemble
A group of parallel model simulations used for *climate projections*. Variation of the results across the ensemble members gives an estimate of *uncertainty*. Ensembles made with the same model but different initial conditions only characterise the uncertainty associated with internal *climate variability*, whereas multi-model ensembles including simulations by several models also include the impact of model differences.

Evaporation
The transition process from liquid to gaseous state.

Extreme weather event
An event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10^{th} or 90th percentile. By definition, the characteristics of what is called 'extreme weather'may vary from place to place. Extreme weather events may typically include floods and *droughts*.

Greenhouse gas
Greenhouse gases are those gaseous constituents of the *atmosphere*, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the *greenhouse effect*. Water vapour (H2O), *carbon dioxide* (CO2), nitrous oxide (N2O), methane (CH4) and *ozone* (O3) are the primary greenhouse gases in the Earth's atmosphere. As well as CO2, N2O, and CH4, the *Kyoto Protocol* deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Heat island
An urban area characterised by ambient temperatures higher than those of the surrounding non-urban area. The cause is a higher absorption of solar energy by materials of the urban fabric such as asphalt.

(climate change) Impact assessment
The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of *climate change* on natural and *human systems*.

(climate change) Impacts
The effects of *climate change* on natural and *human systems*. Depending on the consideration of *adaptation*, one can distinguish between potential impacts and residual impacts:

> **Potential impacts**: all impacts that may occur given a projected change in climate, without considering adaptation.

Residual impacts: the impacts of climate change that would occur after adaptation.

Integrated assessment
An interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines so that all relevant aspects of a complex societal issue can be evaluated and considered for the benefit of decision-making.

Mitigation
An *anthropogenic* intervention to reduce the anthropogenic forcing of the *climate system*; it includes strategies to reduce *greenhouse gas sources* and emissions and enhancing *greenhouse gas sinks*.

No regrets policy
A policy that would generate net social and/or economic benefits irrespective of whether or not *anthropogenic climate change* occurs.

Non-linearity
Aprocess is called ‘non-linear’ when there is no simple proportional relation between cause and effect.

Resilience
The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

Runoff
That part of precipitation that does not *evaporate* and is not *transpired*.

Salt-water intrusion / encroachment
Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to reducing land-based influence (e.g., either from reduced *runoff* and associated *groundwater recharge*, or from excessive water withdrawals from *aquifers*) or increasing marine influence (e.g., *relative sealevel rise*).

Scenario
A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from *projections*, but are often based on additional information from other sources, sometimes combined with a ‘narrative storyline’.

Sea-level rise
An increase in the mean level of the ocean. *Eustatic sea-level rise* is a change in global average sea level brought about by an increase in the volume of the world ocean. *Relative sea-level rise* occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall.

Sensitivity
Sensitivity is the degree to which a system 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*).

Socio-economic scenarios
Scenarios concerning future conditions in terms of population, *Gross Domestic Product* and other socio-economic factors relevant to understanding the implications of *climate change*.

Threshold
The level of magnitude of a system process at which sudden or rapid change occurs. A point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels.

Uncertainty
An expression of the degree to which a value (e.g., the future state of the *climate system*) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain *projections* of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts).

Vulnerability
Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its *sensitivity*, and its adaptive capacity.

Sources

IPCC (2007): Climate Change 2007 - Impacts, Adaptation and Vulnerability. Contribution of working group II to the Forth Assessment report of the Intergovernmental Panel on Climate Change: Glossary