LIFE NADAPTA

THE CLIMA PROJECT

Indicator Dashboard for Monitoring the effects of climate change

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union



Indicator Dashboard for Monitoring the effect of climate change

Acción C.1.1

Grant Agreement nº. LIFE 16 IPC/ES/000001

Towards an integrated, coherent and inclusive implementation of Climate Change Adaptation policy in a region: Navarre

(LIFE-IP NAdapta-CC)

LIFE 2016 INTEGRATED PROJECTS CLIMATE ACTIONS

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Author:

- Lursarea (Nasuvinsa)

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TABLE OF CONTENTS

1. INTRODUCTION 14
2. OBJECTIVES 16
3. TIER I. STRATEGIC DASHBOARD 19
4. TIER II. SECTORAL MONITORING DASHBOARD 19
4.1. Selecting impact chains by sector 19
4.2. Existing indicators per impact chain 24
APPENDIX A. GLOSSARY 41
APPENDIX B. IMPACT CHAIN TABLES 43
Natural environment: Water resources 43
Natural environment: Forest and biodiversity 47
Rural environment: Agriculture and livestock farming / soil 50
Urban environment: Health 53
Urban environment: Cities and town centres 57
Urban environment: Tourism 61
APPENDIX C. DESCRIPTION AND METHODOLOGY FOR CACULATING INDICATORS 62
INDICATOR AS1. Population in municipalities with mechanisms for adapting to climate change 62
INDICATOR AS2 Average annual temperature in Navarra 62
INDICATOR AS3. Annual precipitation in Navarra 62
INDICATOR AS4. Flooding: Damage to property caused by flooding 62
INDICATOR AS5. Water resources: Total water consumption per inhabitant 62
INDICATOR AS6. Fires: Annual hectares burned by forest fires 62
INDICATOR AS7. Health: Hospital intake caused by effects of heat 62
INDICATOR AS8. Agriculture: Variations in yield of main crops 62
INDICATOR 1. Total monthly and annual precipitation (mm) 62
INDICATOR 2. Maximum cumulative precipitation in 1 day (mm) 63
INDICATOR 3. Maximum cumulative precipitation in 5 days (mm) 63
INDICATOR 4. Number of days with precipitation ≥ 20 mm 64

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 5. No. of sewage treatment plants in flood plains 64
INDICATOR 6. Number of homes located at ground level in flood plains 65
INDICATOR 7. Number of premises with Integrated Environmental Authorisation (IEA) in flood plain 65
INDICATOR 8. % of underground surface area (garages) in relation to surface area exposed to floods 65
INDICATOR 9. Inventory of overflow points for run-off water in sanitation systems 66
INDICATOR 10. % of surface area of industrial estates exposed to floods 66
INDICATOR 11. Number of buildings built on a flood plain 66
INDICATOR 12. Number of flooding events 66
INDICATOR 13. Number of days with frost per month and per year 67
INDICATOR 14. People affected by flooding 67
INDICATOR 15. Surface area flooded (ha) 67
INDICATOR 16. Number of improvements in collectors 67
INDICATOR 17. Number of local organisations with self-protection plans 68
INDICATOR 18. Surface area of flood lamination areas (m^2 of expanded river space) 68
INDICATOR 19. Surface area of protected spaces according to INSPIRE directive 68
INDICATOR 20. Concentration of allergenic fungal spores in the atmosphere 69
INDICATOR 21. Standardised Drought-Precipitation Index (IESP) 69
INDICATOR 22. Number of consecutive dry days (RR < 1 mm) 69
INDICATOR 23. Number of visits to companies to analyse the exposure of the working population to extreme temperatures 70
INDICATOR 24. Drought (Precipitation deciles < 30) 70
INDICATOR 25. Intensity of precipitation 70
INDICATOR 26. Mortality attributable to temperature excesses 71
INDICATOR 27. Variation in availability of water resources 71
INDICATOR 28. No. of accidents in the workplace recorded at DELTA relating to exposure to high temperatures 71
INDICATOR 29. No. of municipalities where *Aedes Albopictus* mosquitoes have been detected 72
INDICATOR 30. Indicator for hydrological drought status 72

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 31. Total water consumption per inhabitant (litres/inhabitant/day) 73
INDICATOR 32. Number of regional plans adopted after an evaluation of water resources based on climate change scenarios and patterns of usage and demand 74
INDICATOR 33. Loss of water in distribution networks (increase in efficiency) 74
INDICATOR 34. Usage and consumption index 74
INDICATOR 35. R95pTOT. Total annual precipitation when RR > 95p (mm) 75
INDICATOR 36. R99pTOT. Total annual precipitation when RR > 99p (mm) 75
INDICATOR 37. No. of people with chronic respiratory illness 75
INDICATOR 38. 95th percentile of daily precipitation (mm) 76
INDICATOR 39. Treatment plants with problems caused by rainwater 76
INDICATOR 40. Sewage treatment plants with storm water regulation systems 78
INDICATOR 41. Incidences of overflow in sanitation systems 78
INDICATOR 42. Potential vulnerability of forest areas in the face of climate change 79
INDICATOR 43. Improvements in sewage treatment plants with major problems caused by rain water 79
INDICATOR 44. Average water temperature 79
INDICATOR 45. Surface area of irrigated agriculture 79
INDICATOR 46. Number of tropical nights per year 80
INDICATOR 47. Latitudinal displacement of vineyards 80
INDICATOR 48. Investment in water quality 80
INDICATOR 49. Percentage of days with a high, very high or extreme meteorological risk 81
INDICATOR 50. Rate of danger and importance of protection against fires 81
INDICATOR 51. Percentage of homes in poor condition 82
INDICATOR 52. % surface area of managed forests 82
INDICATOR 53. Rainfall erosivity 83
INDICATOR 54. Annual hectares burned by forest fires 83
INDICATOR 55. Number of water fire extinguisher points 84
INDICATOR 56. Surface area subjected to clearing or cleaning 84
INDICATOR 57. Surface area of forest containing critical points for forest fires 85
INDICATOR 58. Economic cost caused by hail 85

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 59. Surface area occupied by forest varieties that are vulnerable to climate change 85
INDICATOR 60. Köppen climate classification 86
INDICATOR 61. Volume of rainwater retained by SUDS 86
INDICATOR 62. Kilometres of ecological corridors 86
INDICATOR 63. Total investment (€) in special conservation areas 87
INDICATOR 64. Percentage of separate sanitation networks 87
INDICATOR 65. % of native varieties produced out of the total in regional forest nurseries 88
INDICATOR 66. Surface area of agriculture vulnerable to erosion 88
INDICATOR 67. Level of defoliation (%) per species (REFINA) 88
INDICATOR 68. Daily thermal oscillation 89
INDICATOR 69. Non-native invasive species 89
INDICATOR 70. % Mediterranean pine trees infested with pine processionary moths (infestation levels 3, 4 or 5) 89
INDICATOR 71. No. of incidents reported due to pest infestations and diseases in forests 89
INDICATOR 72. Thermal amplitude 90
INDICATOR 73. No. of people over the age of 80 who live alone 90
INDICATOR 74. Percentage of forest affected by defoliation (tier I network) 90
INDICATOR 75. Changes in the distribution of species sensitive to climate change 91
INDICATOR 76. Number of drinking water treatment plants in flood plains 91
INDICATOR 77. Vulnerability of transport networks 91
INDICATOR 78. Variations in the growing period of forest species 91
INDICATOR 79. Increase in surface area with trees resistant to climate change 92
INDICATOR 80. Surface area of dry land agriculture (not returning crop residue to the ground) 92
INDICATOR 81. Surface area of irrigated agriculture vulnerable to high salinity 92
INDICATOR 82. Agricultural surface area per municipality (ha) 93
INDICATOR 83. Adaptation of potential new areas 93
INDICATOR 84. Surface area (m^2) with sustainable drainage systems 93
INDICATOR 85. Variation in water consumption specifically for irrigation (m^3/ha.) 94

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 86. Bioclimatic belts 95
INDICATOR 87. No. of varieties and species introduced which are resistant to drought and tolerant of high temperatures 95
INDICATOR 88. No. of fires per municipality 96
INDICATOR 89. Percentage of area under cultivation with varieties resistant to drought 96
INDICATOR 90. Risk index for landscape mediterraneisation 96
INDICATOR 91. Urban heat island 96
INDICATOR 92. Crop abandonment planning 97
INDICATOR 93. Livestock density (UGM/ha) per municipality 97
INDICATOR 94. Number of livestock units per municipality 97
INDICATOR 95. Risk index for impact on spaces of ecological and scenic interest 97
INDICATOR 96. Reduction in forest fragmentation 98
INDICATOR 97. Livestock units died due to disease 98
INDICATOR 98. Surface area occupied by forest species under a high level of surveillance 98
INDICATOR 99. Risk index for impact on main elements of the forest landscape 99
INDICATOR 100. Expenditure on phytosanitary products applied to crops (€/ha) 99
INDICATOR 101. Number of alerts sent due to animal disease vectors (no./year) 100
INDICATOR 102. Number of alerts sent regarding emerging infestations (no./year) 100
INDICATOR 103. Damage to property caused by flooding 100
INDICATOR 104. Number of people subscribed to alerts regarding emerging pest infestations (no./year) 101
INDICATOR 105. Agricultural surface area (ha) in areas at high risk of fire 102
INDICATOR 106. Annual hectares of soil burned by fires (%) 102
INDICATOR 107. Surface area with silvopasture, pasture and livestock management 102
INDICATOR 108. Agricultural soil exposure to erosion 102
INDICATOR 109. Surface area at risk of desertification 103
INDICATOR 110. Loss of soil due to water erosion 103
INDICATOR 111. Risk index for impact on main elements of the agricultural landscape 104
INDICATOR 112. Surface area with fallow land and mulching for moisture retention and organic material 104

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 113. Storage of soil organic carbon....104
INDICATOR 114. Reduction in erodability of soil....104
INDICATOR 115. Index of change in common bird populations....105
INDICATOR 116. % surface area registered as ecological agriculture....105
INDICATOR 117. Average minimum daily temperature (TNM)....106
INDICATOR 118. Climate change risk to forest landscape components....107
INDICATOR 119. No. of farmers subscribed to alerts service for self-protection against flooding....107
INDICATOR 120. % surface area occupied by species vulnerable to thermal stress and water deficit....107
INDICATOR 121. Progress in foliation, flowering and fruiting of plant species....108
INDICATOR 122. Overall index for risk to landscape....108
INDICATOR 123. Average maximum daily temperature (TXM)....108
INDICATOR 124. % of population aged > 65....109
INDICATOR 125. Area cultivated with plant varieties that are tolerant to abiotic stress....109
INDICATOR 126. No. of consecutive days where Tmax > threshold over a range of dates (dynamic, per crop)....109
INDICATOR 127. Daily thermal integral calculated using temperatures recorded every half an hour (base 10°C and t < 30°C) over a range of dates....109
INDICATOR 128. % of population aged 15 or less....109
INDICATOR 129. Percentage of homes over 40 years old....110
INDICATOR 130. Level of crop exposure to increased water deficit....110
INDICATOR 131. % surface area of green spaces (including forests)....110
INDICATOR 132. Index of risk caused by a change in bioclimatic zone affecting the landscape....110
INDICATOR 133. Energy poverty per CP....110
INDICATOR 134. Variations in yield of main crops....111
INDICATOR 135. CTE Climate zones....111
INDICATOR 136. Linear kilometres of open spaces improved for forest surfaces....111
INDICATOR 137. Urban sky view factor....112
INDICATOR 138. Population density per municipality....112

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 139. Population per municipality 112
INDICATOR 140. Increase in productivity in irrigation farming 113
INDICATOR 141. Density of urban fabric 113
INDICATOR 142. Map of vulnerability in the event of flooding caused by rain 114
INDICATOR 143. No. of days with precipitation in the form of snow 114
INDICATOR 144. NPK mineral fertilisers not used (Kg/ha) - Substituted with organic material 114
INDICATOR 145. Surface area of "cold" roofs and floors 114
INDICATOR 146. =Number of water sources and/or lakes installed 114
INDICATOR 147. Green façades and roofs 115
INDICATOR 148. Surface area of conservation agriculture 115
INDICATOR 149. Surface area that uses organic fertilizer 115
INDICADOR 151. % Variation in mortality rate due to respiratory causes 115
INDICADOR 152. % Variation in mortality rate due to cardiovascular causes 115
INDICATOR 153. Average monthly and annual temperature 115
INDICATOR 154. Emergency hospital admissions due to COPD 116
INDICATOR 158. Green/river/safe routes 116
INDICATOR 160. Number of homes with energy rating A/B/C/D 116
INDICATOR 161. Concentration of potentially allergenic pollen in the atmosphere 117
INDICATOR 162. Emergency hospital admissions due to allergy-induced asthma. Extrinsic asthma 117
INDICATOR 163. Number of people under new climate change monitoring systems (pollen) 117
INDICATOR 164. No. of workers who work outdoors 118
INDICATOR 165. Slope protection (grey infrastructure) 118
INDICATOR 167. No. of days above the alert threshold for Tmax and Tmin 118
INDICATOR 168. Magnitude, amplitude, number, duration and frequency of heat waves 119
INDICATOR 169. Poverty risk rate per Basic Health Zone 119
INDICATOR 170. Hospital intake caused by effects of heat 120
INDICATOR 171. Number of deaths caused by exposure to excessive natural heat 120
INDICATOR 172. Adaptation of evacuation systems in infrastructure (water volume) 120

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 174. Materials in urban fabric (albedo)....120
INDICATOR 175. Number of alerts caused by high temperatures....121
INDICATOR 176. Native and imported cases of malaria, West Nile virus, Lyme disease, Mediterranean spotted fever, dengue fever, Chikungunya virus and Zika virus....122
INDICATOR 177. Economic damage caused by expansion in roads....122
INDICATOR 178. Average annual concentration of particles (PM10)....122
INDICATOR 179. Area of land with invasive vector control (km²)....122
INDICATOR 180. No. of surveillance points for invasive human disease vectors....122
INDICATOR 181. Interior thermal comfort (home)....122
INDICATOR 182. Kilometres of infrastructure in areas at high risk of land slippage....123
INDICATOR 183. Economic damage caused by land displacement....123
INDICATOR 184. Economic damage caused by landslides....123
INDICATOR 185. Number and location of landslides....123
INDICATOR 186. Reducing the gradient of slopes....124
INDICATOR 187. Reforesting slopes....124
INDICATOR 188. Evacuation plans (people)....124
INDICATOR 189. Kilometres of infrastructure in flood plains....124
INDICATOR 191. Percentage of surface area that is impermeable....124
INDICATOR 192. Km of infrastructure affected by floods each year....125
INDICATOR 193. Fire brigade interventions required due to "water damage". Average annual interventions (Rate per 1000 inhabitants)....125
INDICATOR 195. Artificial green area and urban trees....125
INDICATOR 196. Exterior thermal comfort (street)....126
INDICATOR 197. No. of days where thermal sensation thresholds are exceeded....126
INDICATOR 198. Atmospheric dispersal capacity....126
INDICATOR 199. Increase in shade....127
INDICATOR 201. Number of buildings less than 25 metres away from forest areas....127
INDICATOR 202. Percentage of undeveloped land....127
INDICATOR 203. Surface area of empty space per inhabitant....128
INDICATOR 204. Surface area of empty space in relation to urban areas....128

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

INDICATOR 205. Accessibility to primary health care centres....128
INDICATOR 206. Municipality budget (€/inhabitant)....128
INDICATOR 207. Year of municipal planning approval....128
INDICATOR 209. Artificial ground....129
INDICATOR 210. Number of homes per urban area....129
INDICATOR 211. Compactness of urban fabric....129
INDICATOR 212. No. of entities per municipality....129
INDICATOR 214. Industrial plants in flood plains....129
INDICATOR 215. Homes over 40 years old in flood plains....130
INDICATOR 216. Shannon Diversity Index for economic activity....130
INDICATOR 217. Undeveloped land exposed to river flooding....131
INDICATOR 218. Artificial ground exposed to river flooding....131
INDICATOR 219. Surface area of developed land in a flood plain....131
INDICATOR 221. Floodable surface area (Q100 and Q500) per municipality....131
INDICATOR 222. Cooling degree days....132
INDICATOR 223. Heating degree days....132
INDICATOR 224. Indicator for water scarcity per UTE (territorial unit of scarcity)....132
REFERENCES....133

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

TABLES INDEX

Table 1. Equivalence with KLINA sectors 20
Table 2. Number of indicators per KLINA sector and by type considered in this document 21
Table 3. List of existing indicators per impact chain 26
Table 4. Indicator categories. Colour key 43
Table 5. Impact chain relating to the increase in frequency and intensity of river flooding 44
Table 6. Impact chain relating to the impact of climate change on supply and sanitation systems 45
Table 7. Impact chain relating to availability of water resources 45
Table 8. Impact chain relating to the increase in frequency and intensity of forest fires 47
Table 9. Impact chain relating to loss of biodiversity 48
Table 10. Impact chain relating to changes to distribution and magnitude of infestations and diseases 49
Table 11. Impact chain relating to changes to phenology and life cycle 49
Table 12. Indicators for climate change in agriculture associated with different impacts 50
Table 13. Impact chain relating to loss of air quality 53
Table 14. Impact chain relating to the effect of heat waves on the general population 54
Table 15. Impact chain relating to the effect of heat waves on occupational health and safety 55
Table 16. Impact chain relating to vector-borne diseases 56
Table 17. Impact chain relating to the effect of heavy rain on the built environment 57
Table 18. Impact chain relating to the impact of temperature on the built environment 58
Table 19. Impact of climate change on features of the landscape 60
Table 20. Impact chain relating to the impact of climate change on transport infrastructure 61
Table 21. State of repair figures for urban units. Source: Land registry 82
Table 22. MFI values. Source: Arnoldus (1978) 83

The LIFE-IP NAdapta-CC project has received funding from the LIFE Programme of the European Union

FIGURES INDEX

Figure 1. Concept map based on impact chains (created by author based on IPCC)..... 15
Figure 2. Parties responsible for each section (Created by author). In red is the number of indicators included in this document at each tier of the pyramid..... 18
Figure 3. Created by author based on Basque Country Climate Change Strategy to 2050..... 23
Figure 4. Source: AdapteCCa platform. View climate scenarios..... 76
Figure 5. General Forest Fire Statistics (EGIF) per municipality for the period 2001-2014..... 84
Figure 6. IDENA data on livestock routes..... 87
Figure 7. OPCC Geoportal. Vulnerability of Fagus Sylvatica..... 99
Figure 8. Mapping for risk of desertification Source: MAPAMA..... 103
Figure 9. Source: Environment status report by the Government of Navarra [53]..... 105
Figure 10. Sky view factor. Source: [85]..... 112
Figure 11. Exposure to urban heat island. Source: Udalsarea [87]..... 113

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1. INTRODUCTION

The aim of the LIFE-IP-NADAPTA-CC project, "Integrated strategy for adapting to climate change in Navarra", is to propose ways in which Navarra can adapt to the effects of climate change, specifically in the form of 53 actions to be carried out in six different strategic areas: water, forests, agriculture, health, infrastructure, and planning and monitoring.

As part of this project, action C1.1 "Indicator system for monitoring the effects of climate change in Navarra", for which LURSAREA (NASUVINSA) is responsible, aims to design a dashboard to evaluate the territorial impact of climate change in Navarra. This dashboard will show the situation and developments in Navarra with regards to climate change, and will make it possible to identify the effects brought about by the adaptive solutions and changes implemented within the framework of this project.

The LIFE NADAPTA dashboard will form part of the HCCN-KLINA (Roadmap for Climate Change in Navarra), which addresses both adaptation to climate change and mitigation measures, and it is organised into three tiers:

- ✓ Tier I. Strategic monitoring dashboard with relevant conclusions drawn from sectoral results to inform the KLINA Steering Committee, responsible for ensuring action is taken against climate change in Navarra.
- ✓ TIER II. Sectoral monitoring dashboards, which aim to incorporate climate change within the Steering Committees of the relevant local plans (Navarra Energy Plan, Navarra Waste Management etc.).
- ✓ TIER III. Operational dashboards (real-time emissions levels, flood warnings, high temperature alerts etc.). These shall not be included in this document due to their high level of detail. They are more suitable for use in the daily running of services by the Navarra Government.

This document has been agreed and approved by the managers of all divisions of the LIFE NADAPTA project. Specifically, more than 20 meetings have been carried out with a total of over 100 attendees, and with collaborative workshops designed to find synergies with projects focusing on similar issues, such as LIFE Shara or LIFE AgriAdapt. This approach has contributed to reflection on adaptation to climate change in the sectors covered by this project. It would therefore be useful to establish a set of best practices with regards to measures for adapting to climate change in each sector, including measures relating to the different actions of the project and others which arise in the fight against climate change, both in relation to its causes (mitigation action) and its effects (adaptation action).

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The starting point for this document is the assessment and management of climate change risks defined by the Intergovernmental Group of Experts on Climate Change (IPCC). "The risk of impact caused by climate change is derived from the interaction between climate-related dangers (including dangerous episodes and trends) and the vulnerability and exposure of human and natural systems. Changes in the climate system and socio-economic processes, including adaptation and mitigation, are drivers of danger, exposure and vulnerability" [1]. Based on this, and the definitions of each concept given in the IPCC glossary [74], the following concept map has been drawn up, based on impact chains relating to climate change risk factors.

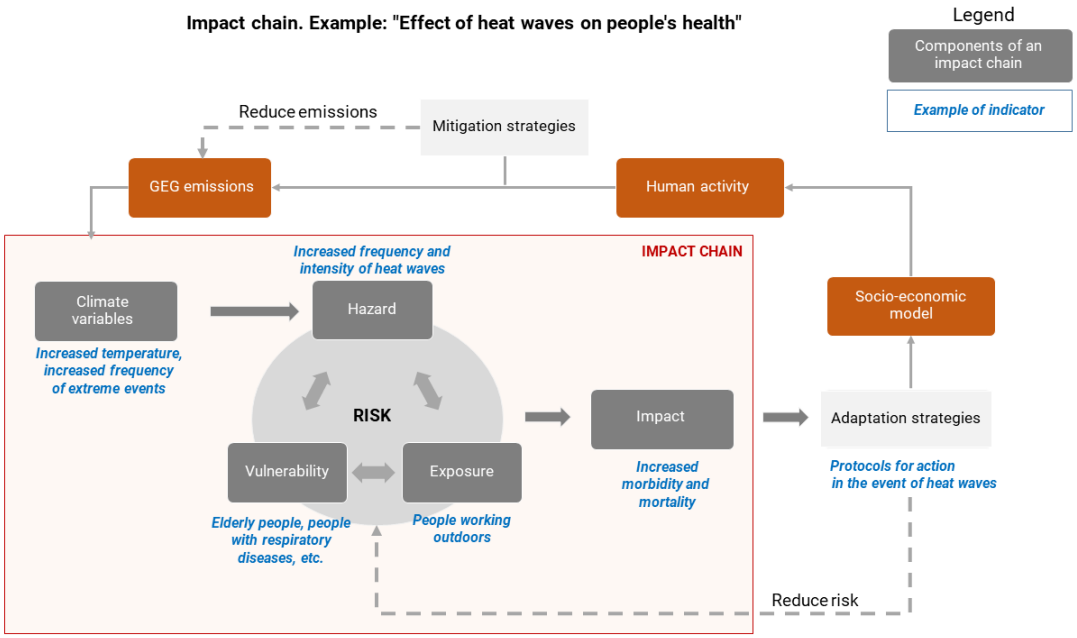


Figure 1. Concept map based on impact chains (created by author based on IPCC)

As can be seen in figure 1, the impact chain associated with each risk factor comprises a series of interconnected elements. Firstly, human activity is responsible for driving climate change through the increase in greenhouse gas emissions (GEI) produced. The mitigation measures for climate change must therefore be focused on reducing the emissions produced by human activity. "However, we are far from seeing a stabilisation in the concentration of greenhouse gases in the atmosphere, and there is a broad consensus among scientists about the future scenarios of climate change in the next few years" [3]. These climate scenarios, embodied in a series of estimated future climate indices, mainly linked to temperature and precipitation, predict a series of risks (heat waves, droughts, river floods, changes in the distribution and intensity of pests and vector-borne diseases, forest fires etc.). Risk is defined as a combination of three factors: vulnerability, exposure and danger.

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"Focussing on risk helps when it comes to making decisions in the context of climate change. People and societies can perceive and prioritise potential risks and benefits in different ways, depending on their different values and objectives" [2]. If this risk materialises, it generates an impact which can have an effect on both natural systems and human systems. In order to reduce these effects when they occur, the measures for adapting to predicted climate change and the initial evidence that we can see from these measures, are considered to be absolutely necessary and should be additional to the mitigating action.

This document therefore follows an approach based on impact chains, and is structured as follows: Section 2 sets out the objectives of action C1.1, focussing on adapting systems for strategic and sectoral management and monitoring. Section 3 presents the strategic indicators for adaptation, structured around the KLINa objectives. Section 4 will then define the sectoral indicators for adaptation associated with the different impact chains, which in turn are linked to the climate change risk factors. These impact chains are organised into 6 sub-sections which match the KLINa sectors. Section 4.2 will include the indicators for those which have existing data and can therefore be calculated.

There will then be additional appendices, including a glossary of terms from the IPCC [74] report (Appendix A), tables listing all of the indicators associated with each impact chain, whether they are existing, recommended or ideal (Appendix B), and a description and methodology for calculating the indicators (Appendix C). Appendix D gives a list of the plans, sectoral strategies and indicator systems which form part of, or which should be included in the indicators, based on the contents of the reference column in section 4.2 of appendix B. finally, there is a list of the references cited throughout the document.

In any case, it is important to highlight that the indicators calculated must be presented disaggregated, territorially by municipality and/or ETN area (Territorial Strategy of Navarra) if data exists for it. Similarly, all indicators must be disaggregated by gender, depending on the availability of data, to incorporate a gender perspective wherever possible.

Finally, it should be noted that it is difficult to separate the effects of climate change from other effects (for example, change in land usage). Similarly, it is not easy to quantify the benefits obtained from the implementation of a specific adaptation measure, as an indicator can often change due to multiple causes.

2. OBJECTIVES

When it comes to monitoring the effects of climate change within the scope of the LIFE NADAPTA project, and specifically action C1.1 "Indicator system for monitoring the effects of climate change in Navarra", the following objectives are key:

Strategic adaptation objectives:

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1. Aim to maximise and facilitate administrative coordination

2. Aim to monitor climate variability in Navarra

3. Aim to monitor and reduce the effects of climate change

Sectoral adaptation objectives:

1. To define the danger for each impact chain (climate variables)

2. To define the exposure and vulnerability for each impact chain

3. To monitor the impact associated with each impact chain

4. To implement adaptation measures for each impact chain

These objectives are consistent with the objectives of KLINA, and in order to evaluate the success of their implementation, we have defined 8 level 1 indicators (section 3) and 206 level 2 indicators (section 4).

The level 1 indicators shall be compiled in collaboration with the KLINA coordination team. In terms of the sectoral objectives, an indicator system has been arranged around the four aforementioned objectives, which have formed the basis of the impact chains associated with the different climatic threats that affect each of the KLINA sectors. As described in the previous section, these impact chains incorporate both climate indices and the exposure, vulnerability, danger, impact and adaptation.

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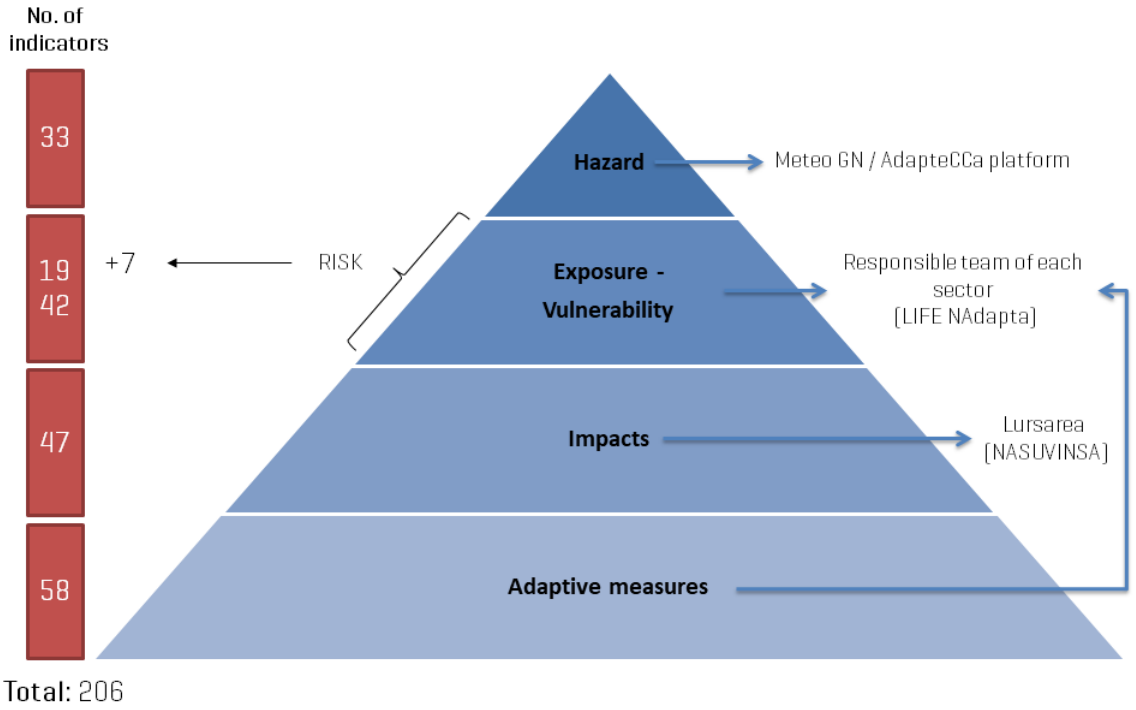


Figure 2. Parties responsible for each section (Created by author). In red is the number of indicators included in this document at each tier of the pyramid.

Figure 2 shows the AdapteCCa platform, funded by the LIFE Shara project, which is responsible for providing the climate indices, both observed and estimated, based on a series of climatic scenarios. Some of these indices are already included on the platform and others will be incorporated in the upcoming contracts for the LIFE SHARA project. On the other hand, Lursarea (NASUVINSA) shall be responsible for collating the indicators of the effects of climate change, focussing on the impact associated with the selected impact chains. Finally, those responsible for each area of the LIFE NADAPTA project shall evaluate and monitor both the exposure and vulnerability, and the adaptation measures adopted in the face of climate change. All of this information shall be integrated into the dashboard for monitoring the effects of climate change, developed by Lursarea (NASUVINSA), which unequivocally shows the effects of climate change and the consequences for the Navarra region.

The governing bodies for the Roadmap for Climate Change in Navarra (KLINA), and specifically the Climate Environment Agencies (UAC) set up in each of the Navarra Government Departments, shall be responsible for monitoring the incorporation of the new indicators into the sectoral plans and strategies. While these are not specifically defined, those responsible for each LIFE NADAPTA sector shall monitor the incorporation of the new indicators into their own management systems.

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The ultimate aim is to establish a management and monitoring system that translates into concrete measures for adapting to the effects of climate change. With the aim of facilitating reflection which leads to establishing a set of best practice guidelines in terms of adapting to climate change within each area, section 4 proposes a series of indicators linked to a specific impact chain. This information is expanded upon in appendix B, which indicates whether this indicator already exists and is integrated into the sectoral management and monitoring system, or whether it is recommended to be calculated and monitored in future.

3. TIER I. STRATEGIC DASHBOARD

Tier I is directed by the KLINA Steering Committee and refers to more general indicators of adaptation to climate change, extracted mostly from Tier II sectoral indicators, alongside indicators that refer to the aim to maximise and facilitate administrative coordination and to monitor climate variability in Navarra. The strategic indicators for adaptation are as follows:

Aim to maximise and facilitate administrative coordination

- ✓ Population in municipalities with mechanisms for adapting to climate change %

Aim to monitor climate variability in Navarra

- ✓ Average annual temperature in Navarra
- ✓ Annual precipitation in Navarra

Aim to reduce the effects of climate change

- ✓ Flooding: Damage to property caused by flooding
- ✓ Water resources: Total water consumption per inhabitant
- ✓ Fires: Annual hectares burned by forest fires
- ✓ Human health: Hospital intake caused by effects of heat
- ✓ Agriculture: Variations in yield of main crops

4. TIER II. SECTORAL MONITORING DASHBOARD

4.1. Selecting impact chains by sector

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The following table shows the relationship between the KLINA sectors, the actions of the LIFE NADAPTA project and the sectors of the National Plan for Adapting to Climate Change (PNACC) [3].

Table 1. Equivalence with KLINA sectors

KLINA – MITIGATION AND ADAPTATION	LIFE NADAPTA – ADAPTATION	PNACC – ADAPTATION
(M) Electricity generation		
(M) Industry		
(M) Transport		
(M) Residential and services		
(M) Primary sector		
(M) Waste		
(A) Natural environment: Water resources	C2	Water resources
(A) Natural environment: Biodiversity and forests	C3	Forests
	*	Biodiversity
	*	Hunting and inland fishing
(A) Natural environment: Soil	C4	Soil / desertification
(A) Rural environment: Agricultural and livestock farming	C4	Agriculture sector
(A) Urban environment: Health	C5	Human health
(A) Urban environment: Tourism	*	Tourism
(A) Urban environment: Cities and town centres	C6	Urban planning and construction
	C6	Transport (infrastructure)
	*	Industry and energy (effect of emperature on air conditioning)
Not listed as a specific sector, but part of other KLINA sectors and where action is being carried out (e.g. Green bonds)		Finance / Insurance

* LIFE NADAPTA does not include adaptation action for these PNACC sectors, but it is considered to be relevant to incorporate these impact chains in the LIFE NADAPTA C1.1 monitoring plan in order to benefit the knock-on effects of the project.

Once this relationship has been ascertained, the table below expresses the number of indicators per KLINA sector and by type (climate variable, vulnerability, exposure, impact and adaptation) considered in this document. In turn, these indicators are split into three categories (existing, minimum recommended and ideal - see Appendix B), with only existing ones listed in section 4.2.

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Table 2. Number of indicators per KLINA sector and by type considered in this document

Sector	Climate variable	Vulnerability	Exposure	Risk	Impact	Adaptation	Total
Natural environment: Water resources	7	5	6	0	7	14	39
Natural environment: Biodiversity and forests	1	6	0	0	10	10	27
Rural environment: Agriculture and livestock farming / Soil	2	6	5	0	9	20	42
Urban environment: Health	2	3	4	0	10	3	22
Urban environment: Cities and town centres	5	22	4	7	11	11	60
Climate	16	0	0	0	0	0	16
Total	**33**	**42**	**19**	**7**	**47**	**58**	**206**

Of the 206 indicators included in this dashboard, 118 have been calculated, of which 113 are published on the monitoring portal, and the rest are included in the "recommended" and "desirable" categories.

4.1.1. Natural environment: Water resources (water)

With regards to water, some potential impacts of climate change on water and water resources have been identified based on the National Plan for Adapting to Climate Change [3]:

- Evaluation of the effect of climate change on extreme hydrological phenomena: Changes in the frequency and intensity of droughts and floods.
- Evaluation of the impact of climate change on supply and sanitation systems.
- Analysis of the economic impact of climate change on the productive uses of water, and on its associated property and environmental services.

This is not an exhaustive list, as there are other impacts which do not fall under the scope of the project, but which would be interesting to study in future, such as an evaluation of the impact of climate change on water resources arising from innovation and, and on hydrogeological resources.

Therefore, based on the National Plan for Adapting to Climate Change (PNACC), the impacts have been broken down into three main impact chains (increase in frequency and intensity of river flooding, impact of climate change on supply and sanitation systems, and availability of water resources), which affect a series of recipients.

- ✓ Increase in frequency and intensity of river flooding
- ✓ Impact of climate change on supply and sanitation systems
- ✓ Availability of water resources

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4.1.2. Natural environment: Biodiversity and forests

The document "Impact, vulnerability and adaptation to climate change in the forest sector" [100] cites six effects or impacts which experts predict will occur in relation to Spanish forests:

- Reduced availability of water as a result of increased evaporation caused by an increase in temperature.
- Increase in the severity of forest fires caused by lower relative humidity in the air due to thermal increase and faster wind speeds.
- Expanding area of activity of pest infestations and diseases limited by cold conditions or periods of activity.
- Changes to the phenology and physiology of tree species, with differing effects on their productivity.
- Increase in the intensity of rainfall, with effects on torrential rain levels and erosion processes.
- Greater frequency of high winds where the wind speed is capable of causing physical damage to woodland.

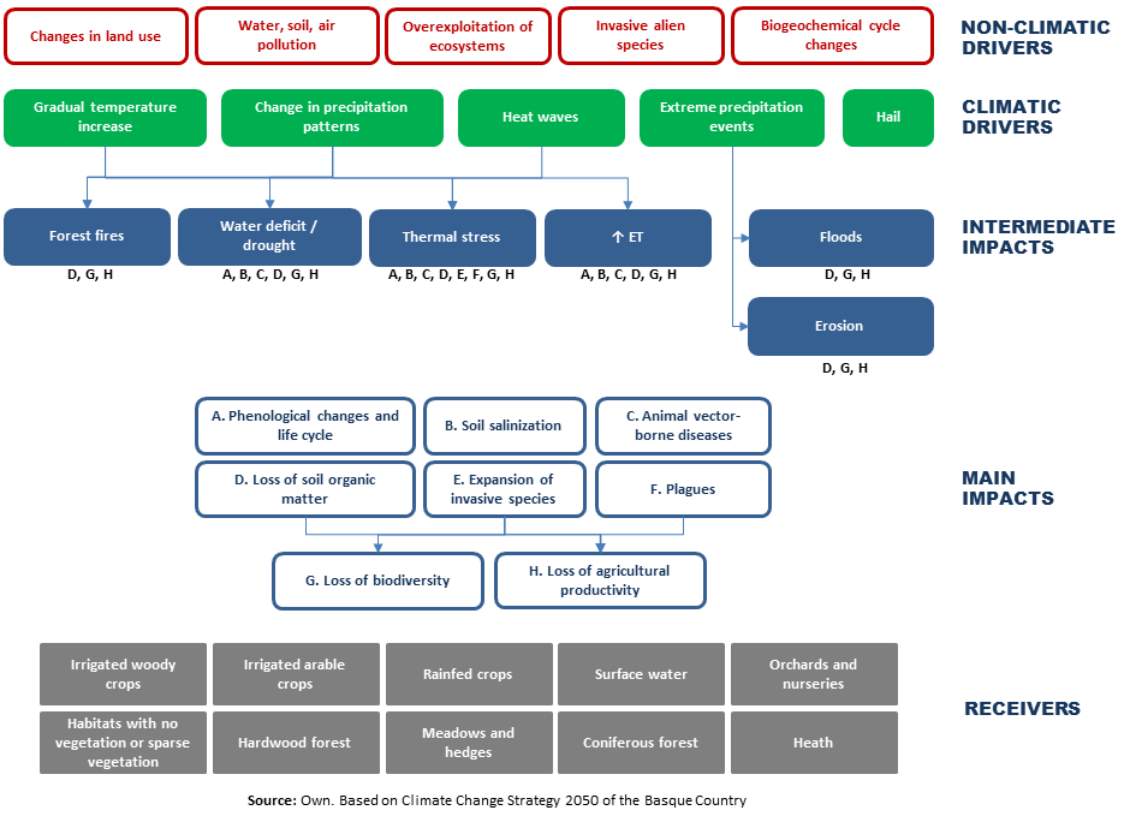
Based on these impacts (excluding the final two, as they are included in other sectors in the case of rainfall intensity, as well as the uncertainty of weather predictions relating to wind), the following impact chains have been selected:

- ✓ Increase in frequency and intensity of forest fires
- ✓ Loss of biodiversity (to be expanded)
- ✓ Changes to distribution and magnitude of infestations and diseases
- ✓ Changes to phenology and life cycle

4.1.3. Rural environment: Agriculture and livestock farming / Soil (agriculture)

In the agriculture sector, it is not easy to separate the different risk factors associated with climate change into separate impact chains, as the various drivers cause a range of different impacts, which are often very closely related to each other. Therefore, in this case, we have opted to follow the plan set out in the Basque Country Climate Change Strategy to 2050 [42], as this work on adapting to climate change has been running for several years and, with the exception of coastal erosion and the increase in sea levels, Navarra also experiences most of the same impacts caused directly or indirectly by climate change.

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Source: Own. Based on Climate Change Strategy 2050 of the Basque Country

Figure 3. Created by author based on Basque Country Climate Change Strategy to 2050

The interim impact caused by climate drivers in turn produce a range of main impacts, identified by letters in figure 3, which affect a series of recipients. Following the plan for the rest of the sectors, the impact chain relating to agriculture, which encompasses all of the aforementioned impacts, shall be:

- ✓ Effects of climate change on the agriculture sector

4.1.4. Urban environment: Health

The document "Health and Climate Change Indicators" [69] has four sections referring to the impacts of climate change on human health:

- Temperatures and Extreme Weather Events
- Vector-Borne Diseases
- Air Quality
- Water Quality

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Based on these sections, four priority impact chains have been identified in the health sector. These are a loss of air quality, the effect of a progressive increase in temperatures and the number of days of duration of heat waves on the general population and on occupational health and safety, and vector-borne diseases. Water quality has already been dealt with in sector C2 Water.

- ✓ Loss of air quality
- ✓ Effect of heat waves on the general population
- ✓ Effect of heat waves on occupational health and safety
- ✓ Vector-borne diseases

4.1.5. Urban environment: Cities and town centres (infrastructure)

In the infrastructure and land planning sector, four priority impact chains have been identified based on the contents of the Manual for urban planning in the Basque Country to mitigate and adapt to climate change [87] with regards to built environment and land planning, and of the Working group for analysing the need to adapt to climate change in the core network of transport infrastructure in Spain [46] with regards to transport infrastructure. In [87] the main extreme weather effects are considered to be heat island effect, floods and rising sea levels. However, the latter does not specifically affect the region of Navarra.

Based on the aforementioned documents, four impact chains have been selected which relate to the effects of climate change which impact the built environment, landscape and infrastructure:

- ✓ Effect of heavy rain on the built environment
- ✓ Impact of temperature on the built environment
- ✓ Impact of climate change on features of the landscape
- ✓ Impact of climate change on transport infrastructure (to be expanded upon from 2020)

As progress is made in LIFE's actions, indicators shall be established in relation to each of the previous impact chains which focus on unique/identifying features of the landscape that are in danger, the dynamic of the landscape and the general uses of the land, the loss of character in landscapes and types of buildings, and of traditional town centres.

4.1.6. Urban environment: Tourism (tourism)

To be developed. Focusing on risks and impact on natural and cultural heritage. Assessment to be made on whether it's included as part of the impact chain for Infrastructure and Land Planning.

4.2. Existing indicators per impact chain

This section presents the climate indexes, indicators for vulnerability, exposure, impact and adaptation measures as part of the impact chains associated with a specific risk factor. Both in the

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case of impact chains and specific indicators, there are cases where duplicates appear, as the same indicator can be included in various impact chains, and one impact chain can be included in various sectors (e.g. river flooding can be included in "Water" and "Infrastructure and town planning").

The "Reference" column cites the source, generally linking to a sectoral plan or strategy (see appendix D). The "Provider" column specifies the provider of the source data and/or indicator being used for the dashboard monitoring the effects of climate change in Navarra. Some impact chains do not include all types of indicators if certain ones are not considered to be relevant, due to the difficulty in identifying a specific climate variable, vulnerability, exposure or impact associated with a certain risk factor. The following table gives a summary of the number of indicators included in this document, per type and per sector:

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Table 3. List of existing indicators per impact chain

Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the danger	Total monthly and annual precipitation (mm)	1	Meteo GN	Meteo GN	
Determine the danger	Maximum cumulative precipitation in 1 day (mm)	2	Meteo GN	Meteo GN	
Determine the danger	Maximum cumulative precipitation in 5 days (mm)	3	Meteo GN	Meteo GN	
Determine the danger	No. of days with precipitation ≥ 20 mm	4	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	No. of sewage treatment plants in flood plains	5	PEERI	NILSA	
Determine the exposure and vulnerability	Number of homes located at ground level in flood plains	6	PEERI	Lursarea	Increase in frequency and intensity of river flooding
Determine the exposure and vulnerability	Number of premises with Integrated Environmental Authorisation (IEA) in flood plain	7	PEERI	Lursarea	
Determine the exposure and vulnerability	No. of drinking water treatment plants in flood plains	76	PEERI	NILSA	
Determine the exposure and vulnerability	Floodable surface area (Q100 and Q500) per municipality	221	PEERI	Lursarea	
Determine the exposure and vulnerability	Number of buildings built on a flood plain	11	SIOTN, PEERI	Lursarea	
Monitoring impact	Damage to property caused by flooding	103	PEERI	Lursarea	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Monitoring impact	Number of flooding events	12	PEERI	Lursarea	
Implementing adaptation measures	No. of local organisations with self-protection plans	17	PEERI	GAN-NIK (C2.5)	
Determine the danger	Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Inventory of overflow points for run-off water in sanitation systems	9	RD 1290/2012	NILSA	
Determine the exposure and vulnerability	Treatment plants with problems caused by rainwater	39	PDCIAUU	NILSA	Impact of climate change on supply and sanitation systems
Implementing adaptation measures	Surface area (m^2) with sustainable drainage systems	84	PDCIAUU	PACES	
Implementing adaptation measures	Sewage treatment plants with storm water regulation systems	40	PDCIAUU	NILSA	
Determine the danger	Total monthly and annual precipitation (mm)	1	Meteo GN	Meteo GN	
Determine the danger	Number of consecutive dry days (RR < 1 mm)	22	Meteo GN	Meteo GN	
Determine the danger	Average monthly and annual temperature	153	Meteo GN	Meteo GN	Availability of water resources
Determine the danger	Indicator for hydrological drought status	30	CHEBRO, CHCANTABRICO	Lursarea / GAN-NIK	
Determine the exposure and vulnerability	Surface area of irrigated agriculture	45	SIGPAC	Lursarea / INTIA	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Monitoring impact	Indicator for water scarcity per UTE (territorial unit of scarcity)	224	CHEBRO, CHCANTABRICO	Lursarea / GAN-NIK	
Implementing adaptation measures	Total water consumption per inhabitant (litres/inhabitant/day)	31	PDCIAUU	NILSA / Lursarea	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	
Determine the danger	No. of days with a high, very high or extreme meteorological risk	49	RMIF	AEMET→ G.N. (Department for the Prevention of Forest Fires)	
Determine the exposure and vulnerability	Distance from town centre to forest area	201	PFN	Lursarea	
Monitoring impact	Annual hectares burned by forest fires	54	EIF	G.N. (Department for the Prevention of Forest Fires)	
Monitoring impact	No. of fires per municipality	88	EIF	G.N. (Department for the Prevention of Forest Fires)	
Implementing adaptation measures	% surface area of managed forests	52	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Implementing adaptation measures	Surface area subjected to clearing or cleaning	56	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Implementing adaptation measures	Linear kilometres of open spaces improved for forest surfaces	136	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Implementing adaptation measures	Number of water fire extinguisher points	55	PFN	G.N. (Department for the Prevention of Forest Fires)	
Implementing adaptation measures	Surface area of forest containing critical points for forest fires	57	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Potential vulnerability of forest areas in the face of climate change	42	IDF / IDENA	G.N. (Department for Strategic Planning of the Natural Environment)	
Implementing adaptation measures	Km of ecological corridors	62	IDENA	G.N. (Department for Strategic Planning of the Natural Environment)	Loss of biodiversity
Implementing adaptation measures	Total investment (€) in special conservation areas	63	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Implementing adaptation measures	% of native varieties produced out of the total in regional forest nurseries	65	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Implementing adaptation measures	Surface area of protected spaces according to INSPIRE directive	19	PGEN	G.N. (Department for Strategic Planning of the Natural Environment)	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Potential vulnerability of forest areas in the face of climate change	42	IDF / IDENA	G.N. (Department for Strategic Planning of the Natural Environment)	
Monitoring impact	Level of defoliation (%) per species (REFINA)	67	IDF	G.N. (Department for Strategic Planning of the Natural Environment)	Changes to distribution and magnitude of infestations and diseases
Monitoring impact	Percentage of forest affected by defoliation (tier I network)	74	IDF	G.N. (Department for Strategic Planning of the Natural Environment)	
Monitoring impact	% Mediterranean pine trees infested with pine processionary moths	70	IDF	G.N. (Department for Strategic Planning of the Natural Environment)	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Monitoring impact	No. of incidents reported due to pest infestations and diseases in forests	71	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Determine the danger	Average maximum temperature (TX)	123*	Meteo GN	Meteo GN	
Determine the danger	Average minimum temperature (TM)	117*	Meteo GN	Meteo GN	Changes to phenology
Monitoring impact	Variations in the growing period of forest species	78	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	and life cycle
Determine the danger	Number of consecutive dry days (RR < 1 mm)	22*	Meteo GN	Meteo GN	
Determine the danger	Maximum cumulative precipitation in 5 days (mm)	3	Meteo GN	Meteo GN	
Determine the danger	Number of days with precipitation ≥ 20 mm	4	Meteo GN	Meteo GN	
Determine the danger	Average monthly and annual temperature	153	Meteo GN	Meteo GN	
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	Effects of climate change on the agriculture sector
Determine the danger	Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Meteo GN	
Determine the danger	Number of days with frost per month and per year	13	Meteo GN	Meteo GN	
Determine the danger	Average maximum temperature (TX)	123*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Agricultural surface area per municipality (%)	82	SIGPAC	Lursarea / INTIA	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the exposure and vulnerability	Livestock density (UGM/ha) per municipality	93	Livestock population	Lursarea / INTIA	
Determine the exposure and vulnerability	Number of livestock units per municipality	94	Livestock population	Lursarea / INTIA	
Monitoring impact	Indicator for hydrological drought status	30*	CHEBRO, CHCANTABRICO	Lursarea / GAN-NIK	
Monitoring impact	Variations in yield of main crops	134	ESYRCE, PEAN	Lursarea / INTIA	
Monitoring impact	Number of alerts sent regarding emerging pest infestations	102	PDR	INTIA	
Implementing adaptation measures	Variation in water consumption specifically for irrigation (m^3/ha.)	85	PDR	INTIA (Irrigation)	
Implementing adaptation measures	No. of people subscribed to alerts regarding emerging pest infestations	104	PDR, PEAN	INTIA	
Implementing adaptation measures	Number of water fire extinguisher points	55*	PFN	G.N. (Department for the Prevention of Forest Fires)	
Implementing adaptation measures	Surface area with silvopasture, pasture and livestock management	107	PDR, PEAN	MCA→Lursarea /INTIA	
Implementing adaptation measures	% surface area registered as ecological agriculture	116	PEAN	CPAEN → Lursarea / INTIA	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	Loss of air quality

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Concentration of potentially allergenic pollen in the atmosphere	161	PSN	ISPLN	
Determine the exposure and vulnerability	Concentration of allergenic fungal spores in the atmosphere	20	PSN	ISPLN	
Determine the exposure and vulnerability	Population per municipality	139	NASTAT	Lursarea	
Monitoring impact	Emergency hospital admissions due to allergy-induced asthma. Extrinsic asthma	162	PSN	ISPLN	
Monitoring impact	Emergency hospital admissions due to COPD	154	PSN	ISPLN	
Determine the danger	No. of days above the alert threshold for T_{max} and T_{min}	167	PSN	ISPLN	
Determine the exposure and vulnerability	No. of workers who work outdoors	164	PNSL	ISPLN	
Monitoring impact	No. of accidents in the workplace recorded at DELTA relating to exposure to high temperatures	28	PNSL	ISPLN	Effect of heat waves on occupational health and safety
Implementing adaptation measures	Number of visits to companies to analyse the exposure of the working population to extreme temperatures	23	PNSL	ISPLN	
Determine the danger	No. of days above the alert threshold for T_{max} and T_{min}	167	PSN	ISPLN	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the danger	Number of alerts caused by high temperatures	175	PSN	ISPLN	
Determine the exposure and vulnerability	No. of people over the age of 80 who live alone	73	PSN	ISPLN / OSCN	
Determine the exposure and vulnerability	Poverty risk rate per Basic Health Zone	169	PSN	ISPLN / OSCN	Effect of heat waves on the general population
Monitoring impact	Hospital intake caused by effects of heat	170	PSN	ISPLN	
Monitoring impact	Mortality attributable to temperature excesses	26	PSN	MOMO-ISCIII	
Monitoring impact	Number of deaths caused by exposure to excessive natural heat	171	PSN	ISPLN	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	No. of municipalities where *Aedes Albopictus* mosquitoes have been detected	29	PSN	ISPLN	Vector-borne diseases
Monitoring impact	Native and imported cases of malaria, West Nile virus, Lyme disease, Mediterranean spotted fever, dengue fever, Chikungunya virus and Zika virus	176	ISCC	ISPLN	
Implementing adaptation measures	No. of surveillance points for invasive human disease vectors	180	PSN	ISPLN	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the exposure and vulnerability	Number of buildings built on a flood plain	11	PEERI	Lursarea	
Determine the exposure and vulnerability	Industrial plants in flood plains	214	PEERI	Lursarea	
Determine the exposure and vulnerability	Homes over 40 years old in flood plains	215	PEERI	Lursarea	
Determine the exposure and vulnerability	Shannon Diversity Index for economic activity	216	PEERI	Lursarea	
Determine the exposure and vulnerability	Undeveloped land exposed to river flooding	217	PEERI	Lursarea	Effect of heavy rain on the built environment
Determine the exposure and vulnerability	Artificial ground exposed to river flooding	218	PEERI	Lursarea	
Determine the exposure and vulnerability	Surface area of developed land in a flood plain	219	PEERI	Lursarea	
Determine the danger	Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Kilometres of infrastructure in flood plains	189	PEERI	Lursarea	
Determine the danger	Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Percentage of surface area that is impermeable	191	PEERI	Lursarea	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Implementing adaptation measures	No. of local organisations with self-protection plans	17	PEERI	GAN-NIK (C2.5)	
Implementing adaptation measures	Surface area (m^2) with sustainable drainage systems	84	PDCIAUU	PACES	
Implementing adaptation measures	Percentage of homes in poor condition	51	PEV	Lursarea	
Determine the danger	Average monthly and annual temperature	153	Meteo GN	Meteo GN	
Determine the danger	Number of tropical nights	46	Meteo GN	Meteo GN	
Determine the danger	Magnitude, amplitude, number, duration and frequency of heat waves	168	Meteo GN	Meteo GN	
Determine the exposure and vulnerability	Homes over 40 years old	208	PEV	Lursarea	
Determine the exposure and vulnerability	Artificial ground	209	SIOTN	Lursarea	
Determine the exposure and vulnerability	Number of homes per urban area	210	PEV	Lursarea	Impact of temperature on the built environment
Determine the exposure and vulnerability	Compactness of urban fabric	211	SIOTN	Lursarea	
Determine the exposure and vulnerability	No. of entities per municipality	212	NASTAT	NASTAT	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the exposure and vulnerability	Accessibility to primary health care centres	205	SIOTN	Lursarea	
Determine the exposure and vulnerability	Municipality budget (€/inhabitant)	206		NASTAT	
Determine the exposure and vulnerability	Year of municipal planning approval	207	SIUN	Lursarea	
Determine the exposure and vulnerability	Surface area of empty space in relation to urban areas	204	SIOTN	Lursarea	
Determine the exposure and vulnerability	Surface area of empty space per inhabitant	203	SIOTN	Lursarea	
Determine the exposure and vulnerability	Percentage of undeveloped land	202	SIOTN	Lursarea	
Determine the exposure and vulnerability	% of population aged 65 or over	124	NASTAT	NASTAT	
Determine the exposure and vulnerability	% of population aged 15 or less	128	NASTAT	NASTAT	
Determine the exposure and vulnerability	% of homes over 40 years old	129	PEV	Lursarea	
Determine the exposure and vulnerability	No. of people over the age of 80 who live alone	73*	PSN	ISPLN / OSCN	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the exposure and vulnerability	Poverty risk rate per Basic Health Zone	169*	PSN	ISPLN / OSCN	
Determine the exposure and vulnerability	Population density per municipality	138	SIOTN	Lursarea	
Determine the exposure and vulnerability	Population per municipality	139	NASTAT	Lursarea	
Determine the exposure and vulnerability	Density of urban fabric	141	SIOTN	Lursarea	
Monitoring impact	Cooling degree days	222	PEV	Lursarea	
Monitoring impact	Heating degree days	223	PEV	Lursarea	
Monitoring impact	Urban heat island	91	PEV	Lursarea	
Implementing adaptation measures	Artificial green area and urban trees	195	PIV	Lursarea	
Implementing adaptation measures	Percentage of homes in poor condition	51*	PEV	Lursarea	
Implementing adaptation measures	Number of homes with energy rating A/B/C/D	160	PEV	Lursarea	
Determine the danger	Köppen climate classification	60	Lursarea	Lursarea	
Determine the danger	Average monthly and annual temperature	153*	Meteo GN	Meteo GN	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Determine the danger	Total monthly and annual precipitation	1*	Meteo GN	Meteo GN	
Determine the danger	Bioclimatic zones	86	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Index of risk caused by a change in bioclimatic zone affecting the landscape	132	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Risk index for landscape mediterraneisation	90	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Risk index for impact on spaces of ecological and scenic interest	95	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Risk index for impact on main elements of the forest landscape	99	Lursarea	Sigmatec	Impact of climate change on features of the landscape
Determine the exposure and vulnerability	Risk index for impact on main elements of the agricultural landscape	111	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Climate change risk to forest landscape components	118	Lursarea	Sigmatec	
Determine the exposure and vulnerability	Overall index for risk to landscape	122	Lursarea	Sigmatec	
Monitoring impact	Latitudinal displacement of vineyards	47	Lursarea	Lursarea	
Monitoring impact	Variations in yield of vineyards	134**	ESYRCE, PEAN	Lursarea / INTIA	

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Goal	Indicator	Code	Reference	Provider	Impact chain
Monitoring impact	Variations in the growing period of forest species	78*	PFN	G.N. (Department for Strategic Planning of the Natural Environment)	
Monitoring impact	Annual hectares burned by forest fires	54*	EIF	G.N. (Department for the Prevention of Forest Fires)	

APPENDIX A. GLOSSARY

Definitions listed in the glossary for *"Climate Change 2013. Physical basis. Contribution by Working group I to the Fifth Evaluation Report of the Intergovernmental Group of Experts on Climate Change"* [74]:

Risk: The possibility, if the outcome is uncertain, that adverse consequences shall impact life; livelihoods; health; ecosystems and species; economic, social and cultural assets; services and infrastructure.

Impact: Effects on natural and human systems. This is mainly used to describe the effects of extreme climatic and meteorological episodes and climate change on natural and human systems.

Danger: The potential occurrence of a physical event or tendency, of natural or human origin, or a physical impact, which could cause injury, loss of life or have other negative effects on health, as well as loss or damage to property, infrastructure, ecosystems, environmental resources etc.

Exposure: The presence of people; livelihoods; species or ecosystems; functions; environmental services and resources; infrastructure, or economic, social or cultural assets in places and environments that could be negatively affected. In the health sector, the most commonly accepted level of exposure refers to *"Concentration, quantity or intensity of a particular physical, chemical or biological agent, including in a population, organism, organ or target cell; it is usually expressed in quantitative terms of concentration, duration and frequency (for chemical and microbiological agents) or intensity (for physical agents)".* In this project, it was therefore decided to adapt the impact chains corresponding to the health sector to be in line with this level of acceptance, instead of that defined by the IPCC.

Vulnerability: A propensity or predisposition to be negatively affected. Vulnerability comprises a variety of concepts and factors, including sensitivity or susceptibility to damage and an inability to respond and adapt.

Mitigation: Human intervention aimed at reducing the sources or increasing the sinks of greenhouse gases.

Adaptation: The process of adjusting to the current or predicted climate and its effects. In human systems, adaptation involves mitigating or preventing damage, or making the most of beneficial opportunities.

Impact chain: This involves creating a link between a climate threat (e.g. a heat wave or flood) and a recipient (human health or infrastructure and economic activity). For each impact chain, corresponding indicators are selected; there can be specific indicators for each individual impact chain, or they can be shared among several chains.

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APPENDIX B. IMPACT CHAIN TABLES

Indicators which have already been calculated or for which there is an existing data source have been highlighted in white (in blue is the static data which only shows a fixed picture, or data which is not expected to change much). The rest of the indicators are divided into those which are currently not yet integrated into the respective management and monitoring systems for each area, but which should be incorporated (in green), and the rest of the indicators which could be included in an ideal situation (in blue). As a final observation, the type of indicator corresponds to each of the four objectives.

Table 4. Indicator categories. Colour key

Colour	Indicator	Location in document
White	Existing	Section 4 & Appendix B
Green	Recommended	Appendix B
Blue	Desirable	Appendix B

Natural environment: Water resources

Increase in frequency and intensity of river flooding

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Table 5. Impact chain relating to the increase in frequency and intensity of river flooding

Type	Indicator	Code	Reference	Provider
Climate variable	- Total monthly and annual precipitation (mm)	1	Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 1 day (mm)	2	Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 5 days (mm)	3	Meteo GN	Meteo GN
	- No. of days with precipitation ≥ 20 mm	4	Meteo GN	Meteo GN
Vulnerability	- No. of sewage treatment plants in flood plains	5	PEERI	Lursarea / PDCIAUU
	- No. of drinking water treatment plants in flood plains	76	PEERI	Lursarea / PDCIAUU
	- Number of homes located at ground level in flood plains	6	PEERI	Lursarea
	- Number of premises with Integrated Environmental Authorisation (IEA) in flood plain	7	PEERI	Lursarea
	- % of underground surface area in relation to surface area exposed to floods	8		Lursarea
	- % of surface area of industrial estates exposed to floods	10		Lursarea
	- Number of buildings built on a flood plain	11	SIOTN, PEERI	Lursarea
	- Industrial plants in flood plains	214	PEERI	Lursarea
Exposure	- Floodable surface area (Q100 and Q500) per municipality	221	PEERI	Lursarea
Impact	Damage to property caused by flooding	103	PEERI	Lursarea
	- People affected by flooding	14		Lursarea
	- Number of flooding events	12	PEERI	Lursarea
	- Surface area flooded (ha)	15		Lursarea
Adaptation	- No. of local organisations with self-protection plans	17	PEERI	GAN-NIK (C2.5)
	- Surface area (ha) of flood lamination areas (m² of expanded river space)	18	PEERI	G.N SECA (C2.6)

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Table 6. Impact chain relating to the impact of climate change on supply and sanitation systems

Type	Indicator	Code	Reference	Provider
Climate variable	- Total annual precipitation when RR > 95p (mm)	35	Meteo GN	Meteo GN
	- Total annual precipitation when RR > 99p (mm)	36	Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Lursarea /Meteo GN
	- Total monthly and annual precipitation (mm)	1*	Meteo GN	Lursarea /Meteo GN
	- Intensity of precipitation	25	Meteo GN	Meteo GN
	- 95th percentile of daily precipitation (mm)	38	Meteo GN	Meteo GN
Vulnerability	- Map of vulnerability in the event of flooding caused by rain	142		G.N. (SECA)
	- Inventory of water overflow points in sanitation systems	9	RD 1290/2012	NILSA
	- Treatment plants with problems caused by rainwater	39	PDCIAUU	NILSA
Exposure				
Impact	- Incidences of overflow in sanitation systems	41	PDCIAUU	NILSA
	- Improvements in sewage treatment plants with major problems caused by rain water	43		NILSA
Adaptation	- Sewage treatment plants with storm water regulation systems	40	PDCIAUU	NILSA
	Volume of rainwater retained by SUDS	61	C2.3 action	NILSA
	- Surface area (m²) with sustainable drainage systems	84		PACES
	Percentage of separate sanitation networks	64	PDCIAUU	

Availability of water resources

Table 7. Impact chain relating to availability of water resources

Type	Indicator	Code	Reference	Provider
Climate variable	- Total monthly and annual precipitation	1	Meteo GN	Meteo GN
	- Standardised Drought-Precipitation Index (IESP)	21		Meteo GN
	- Number of consecutive dry days (RR < 1 mm)	22	Meteo GN	Meteo GN
	- Drought (Precipitation deciles < 30)	24	PEAN	Meteo GN

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	- Indicator for hydrological drought status	30		Lursarea / GAN-NIK
Vulnerability	- Surface area of irrigated agriculture	45	SIGPAC	Lursarea / INTIA
Impact	- Variation in availability of water resources	27	PDCIAUU	G.N. SECA (C2.7)
	- Indicator for water scarcity per UTE (territorial unit of scarcity)	224		Lursarea / GAN-NIK
Adaptation	- Total water consumption per inhabitant (litres/inhabitant/day)	31	PDCIAUU	PDCIAUU / Regions
	- No. of regional plans adopted after an evaluation of water resources based on CC scenarios and patterns of usage and demand	32	PDCIAUU	GAN-NIK
	- Investment in water quality	48		G.N. SECA / GAN-NIK
	- Loss of water in distribution networks (increase in efficiency)	33		Local administration / G.N. SECA
	- Usage and consumption index	34		Local administration / G.N. SECA

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Table 8. Impact chain relating to the increase in frequency and intensity of forest fires

Type	Indicator	Code	Reference	Provider
Climate variable	- Average monthly and annual temperature	153*	Meteo GN	Meteo GN
	- No. of days with a high, very high or extreme meteorological risk	49	RMIF	AEMET→ G.N. (Department for the Prevention of Forest Fires)
Vulnerability	- Map of vulnerability in the event of fires	50	EIF	G.N. (Department for the Prevention of Forest Fires)
Exposure	- Distance from town centre to forest area	201		Lursarea / G.N. (Department for the Prevention of Forest Fires)
Impact	- Annual hectares burned by forest fires	54	EIF	G.N. (Department for the Prevention of Forest Fires)
	- No. of fires per municipality	88	EIF	G.N. (Department for the Prevention of Forest Fires)
Adaptation	- % surface area of managed forests	52	PFN	G.N. (Department for Strategic Planning of the Natural Environment)
	- Number of water fire extinguisher points	55	PFN	G.N. (Department for the Prevention of Forest Fires)
	- Surface area subjected to clearing or cleaning	56	PFN	G.N. (Department for the Prevention of Forest Fires)
	- Linear kilometres of open spaces improved for forest surfaces	136	PFN	G.N. (Department for the Prevention of Forest Fires)
	- Surface area of forest containing critical points for forest fires	57	PFN	G.N. (Department for Strategic Planning of the Natural Environment)

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Loss of biodiversity

Table 9. Impact chain relating to loss of biodiversity

Type	Indicator	Code	Reference	Provider
Climate variable	- Average monthly and annual temperature	153	Meteo GN	Meteo GN
	- Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN
Vulnerability	Potential vulnerability of forest areas in the face of climate change	42	IDF / IDENA	G.N. (Department for Strategic Planning of the Natural Environment)
	- Surface area occupied by forest varieties that are vulnerable to climate change	59	PFN	G.N. (Department for the Prevention of Forest Fires)
	Surface area occupied by forest species under a high level of surveillance	98		G.N. (Department for Strategic Planning of the Natural Environment)
Exposure				
Impact	- Index of change in common bird populations	115	PDR	SEOBIRDLIFE →Lursarea
	- Changes in the distribution of species sensitive to climate change	75		G.N. (Department for Strategic Planning of the Natural Environment)
Adaptation	- km of ecological corridors (ecological connectivity)	62	IDENA	IDENA
	- Total investment (€) in special conservation areas	63	PGEN	G.N. (Environment Department)
	- % of native varieties produced out of the total in regional forest nurseries	65	PFN	G.N. (Environment Department)
	- Surface area of protected spaces according to INSPIRE directive	19	PGEN	G.N. (Environment Department)
	- Increase in surface area with trees resistant to climate change	79		G.N. (Environment Department)
	- Reduction in forest fragmentation	96		G.N. (Environment Department)
	- Adaptation of potential new areas	83		G.N. (Environment Department)

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Changes to distribution and magnitude of infestations and diseases

Table 10. Impact chain relating to changes to distribution and magnitude of infestations and diseases

Type	Indicator	Code	Reference	Provider
Climate variable	- Total monthly and annual precipitation (mm) - Average monthly and annual temperature	1* 153*	Meteo GN Meteo GN	Meteo GN Meteo GN
Vulnerability	Potential vulnerability of forest areas in the face of climate change	42	IDF / IDENA	G.N. (Department for Strategic Planning of the Natural Environment)
Exposure				
Impact	- Level of defoliation (%) per species (REFINA)	67	IDF	G.N. (Department for Strategic Planning of the Natural Environment)
	- Percentage of forest affected by defoliation (tier I network)	74	IDF	G.N. (Department for Strategic Planning of the Natural Environment)
	- Non-native invasive species	69	IDF	G.N. (Department for Strategic Planning of the Natural Environment)
	- % Mediterranean pine trees infested with pine processionary moths	70	IDF	G.N. (Department for Strategic Planning of the Natural Environment)
	- No. of incidents reported due to pest infestations and diseases in forests	71	PFN	G.N. (Department for Strategic Planning of the Natural Environment)
Adaptation				

Changes to phenology and life cycle

Table 11. Impact chain relating to changes to phenology and life cycle

Type	Indicator	Code	Reference	Provider

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Climate variable	- Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN
	- Average monthly and annual temperature	153*	Meteo GN	Meteo GN
Vulnerability				
Exposure				
Impact	- Variations in the growing period of forest species	78	PFN	G.N. (Department for Strategic Planning of the Natural Environment)
Adaptation				

Rural environment: Agriculture and livestock farming / soil

Table 12. Indicators for climate change in agriculture associated with different impacts

Type	Indicator	Code	Impacts	Reference	Provider
Climate variable	- Standardised Drought-Precipitation Index (IESP)	21*	A,B,C,D,G,H		
	- Number of consecutive dry days (RR < 1 mm)	22*	A,B,C,D,G,H	Meteo GN	Meteo GN
	- Drought (Precipitation deciles < 30)	24*	A,B,C,D,G,H	Meteo GN	Meteo GN
	- No. of days with a high, very high or extreme meteorological risk	49*	D, G, H	RMIF	AEMET
	- Total monthly and annual precipitation	1*	D,G,H	AdapteCCa/Meteo GN	Meteo GN
	- Rainfall erosivity	53	D,G,H		Meteo GN
	- Maximum cumulative precipitation in 1 day (mm)	2*	D,G,H	AdapteCCa/Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 5 days (mm)	3*	D,G,H	AdapteCCa/Meteo GN	Meteo GN
	- Number of days with precipitation ≥ 20 mm	4*	D,G,H	AdapteCCa/Meteo GN	Meteo GN
	- No. of consecutive days where T_{max} > threshold over a range of dates	126	A,G		AdapteCCa
	- Daily thermal integral calculated using temperatures recorded every half an hour (base 10°C and t < 30°C) over a range of dates	127	A,G		AdapteCCa
	Number of days with frost per month and per year	13	A,G		Meteo GN
Vulnerability	- Surface area of dry land agriculture (not returning crop residue to the ground)	80	ALL		INTIA / UPNA

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Type	Indicator	Code	Impacts	Reference	Provider
	- Surface area of irrigated agriculture vulnerable to high salinity	81	ALL		INTIA / UPNA
	- Surface area of agriculture vulnerable to erosion	66	D,G,H		INTIA / UPNA
	- % surface area with species vulnerable to thermal stress and water deficit	120	A,H	PEAN	INTIA / UPNA
Exposure	- Agricultural surface area per municipality (%)	82	ALL	SIGPAC	Lursarea / INTIA
	- . Livestock density (UGM/ha.) per municipality	93	C	Livestock population	Lursarea / INTIA
	Number of livestock units per municipality	94	C	Livestock population	Lursarea / INTIA
	- Agricultural soil exposure to erosion	108	D,G,H	PEAN	INTIA/UPNA
	- Agricultural surface area (ha) in areas at high risk of fire	105	D,G,H		Lursarea
	- Surface area at risk of desertification	109	D,G,H		Meteo GN
	- Level of crop exposure to increased water deficit	130	H	PEAN	INTIA
Impact	- Variation in availability of water resources	27*	A,B,C,D,G,H	PREGN	GAN-NIK
	- Usage and consumption index	34*	A,B,C,D,G,H	PREGN,PEAN	NILSA
	- Indicator for hydrological drought status	30*	A,B,C,D,G,H		Lursarea /GAN-NIK
	- Livestock units died due to disease	97	C		INTIA
	- Annual hectares of soil burned by fires	106	D,G,H	IDF	Lursarea
	- Loss of soil due to water erosion	110	D,G,H		Environment Department G.N.
	- Index of change in common bird populations	115	D,G,H	PDR	SEOBIRDLIFE →Lursarea
	- Economic cost caused by floods	103*	G	PEERI	Lursarea
	- People affected by flooding	14*	D,G,H		Lursarea
	- Surface area flooded (ha)	15*	D,G,H	PEERI	Lursarea
	- Progress in foliation, flowering and fruiting of plant species	121	D,G,H	PDR, PEAN	INTIA
	- Variations in yield of main crops	134	A,G	ESYRCE, PEAN	Lursarea / INTIA
	- No. of alerts sent due to animal disease vectors	101	C		INTIA
	- Number of alerts sent regarding emerging pest infestations	102	F	PDR, PEAN	INTIA
	- Economic cost caused by hail	58	H		INTIA
Adaptation	- Variation in water consumption specifically for irrigation (m^3/ha.)	85		PDR	INTIA

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Type	Indicator	Code	Impacts	Reference	Provider
	- No. of varieties and species introduced which are resistant to drought and tolerant of high temperatures	87	H	PDR, PEAN	INTIA
	- Percentage of area under cultivation with varieties resistant to drought	89	H	PDR,PEAN	INTIA / UPNA
	- Crop abandonment planning	92	H,G		INTIA
	- Expenditure on phytosanitary products applied to crops	100	F		INTIA
	- No. of people subscribed to alerts regarding emerging pest infestations	104	F	PDR, PEAN	INTIA
	- Number of water fire extinguisher points	55*	D,G,H		G.N. (Department for the Prevention of Forest Fires)
	- Surface area with silvopasture, pasture and livestock management	107	D,G,H	PDR, PEAN	MCA→Lursarea /INTIA
	- Surface area with fallow land and mulching for moisture retention and organic material	112	D,G,H		INTIA/UPNA
	- Storage of soil organic carbon	113	D,G,H		INTIA/UPNA
	- Reduction in erodability of soil	114	D,G,H		INTIA/UPNA
	- % surface area registered as ecological agriculture	116	G	PEAN	CPAEN → Lursarea / INTIA
	No. of local organisations with self-protection plans against flooding	17*	D,G,H	PDR, PEAN	GAN-NIK
	No. of farmers subscribed to alerts service for self-protection against flooding	119	D,G,H		G.N. SECA
	- Area cultivated with plant varieties that are tolerant to abiotic stress	125	B,D,G,H	PDR, PEAN	INTIA/UPNA
	- Increase in productivity in irrigation farming	140	H		INTIA (Irrigation)
	- NPK mineral fertilisers not used. Substituted with organic material	144	D	PDR, PEAN	INTIA
	- Surface area of conservation agriculture	148	D	PDR, PEAN	INTIA
	- Surface area that uses organic fertilizer	149	D	PDR, PEAN	INTIA

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Urban environment: Health

Loss of air quality

Table 13. Impact chain relating to loss of air quality

Type	Indicator	Code	Reference	Provider
Climate variable	- Average monthly and annual temperature	153*	Meteo GN	Meteo GN
	- Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN
Vulnerability	- No. of people with chronic respiratory illness	37		ISPLN
Exposure	- Concentration of potentially allergenic pollen in the atmosphere	161	PSN	ISPLN
	- Concentration of allergenic fungal spores in the atmosphere	20	PSN	ISPLN
	Population per municipality	139	NASTAT	Lursarea
Impact	- % variation in mortality rate due to respiratory causes	151	PSN	ISPLN
	- % variation in mortality rate due to cardiovascular causes	152	PSN	ISPLN
	- Emergency hospital admissions due to allergy-induced asthma. Extrinsic asthma	162	PSN	ISPLN
	- Emergency hospital admissions due to COPD	154	PSN	ISPLN
Adaptation	No. of people under new climate change monitoring systems (pollen)	163	PSN	ISPLN

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Table 14. Impact chain relating to the effect of heat waves on the general population

Type	Indicator	Code	Reference	Provider
Climate variable	- Number of alerts caused by high temperatures	175	PSN	ISPLN
	- No. of days above the alert threshold for T_{max} and T_{min}	167	PSN	ISPLN
Vulnerability	- No. of people over the age of 80 who live alone	73	PSN	ISPLN / OSCN
	- Poverty risk rate per Basic Health Zone	169	PSN	ISPLN / OSCN
Exposure				
Impact	- Hospital intake caused by effects of heat	170	PSN	ISPLN
	Mortality attributable to temperature excesses	26	PSN	MOMO-TEMP
	- Number of deaths caused by exposure to excessive natural heat	171	PSN	ISPLN
Adaptation				

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Table 15. Impact chain relating to the effect of heat waves on occupational health and safety

Type	Indicator	Code	Reference	Provider
Climate variable	- Number of alerts caused by high temperatures	175	PSN	ISPLN
	- No. of days above the alert threshold for T_{max} and T_{min}	167	PSN	ISPLN
Vulnerability	- No. of workers who work outdoors	164	PNSL	ISPLN
Exposure				
Impact	- No. of accidents in the workplace recorded at DELTA relating to exposure to high temperatures	28	PNSL	ISPLN
Adaptation	Number of visits to companies to analyse the exposure of the working population to extreme temperatures	23	PNSL	ISPLN

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Table 16. Impact chain relating to vector-borne diseases

Type	Indicator	Code	Reference	Provider
Climate variable	- Average monthly and annual temperature	153*	Meteo GN	Meteo GN
	- Total monthly and annual precipitation (mm)	1*	Meteo GN	Meteo GN
Vulnerability				
Exposure	- No. of municipalities where *Aedes Albopictus* mosquitoes have been detected	29	PSN	ISPLN
Impact	- Native and imported cases of malaria, West Nile virus, Lyme disease, Mediterranean spotted fever, dengue fever, Chikungunya virus and Zika virus	176	ISCC	ISPLN
Adaptation	- Area of land with invasive vector control (km^2)	179	PSN	ISPLN
	- No. of surveillance points for invasive human disease vectors	180	PSN	ISPLN

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Table 17. Impact chain relating to the effect of heavy rain on the built environment

Type	Indicator	Code	Reference	Provider
Climate variable	- Total monthly and annual precipitation	1*	Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Meteo GN
	- Maximum cumulative precipitation in 5 days (mm)	3*	Meteo GN	Meteo GN
	- No. of days with precipitation ≥ 20 mm	4*	Meteo GN	Meteo GN
Vulnerability	- Homes over 40 years old in flood plains	215	PEERI	Lursarea
	- Shannon Diversity Index for economic activity	216	PEERI	Lursarea
	- Number of homes located at ground level in flood plains	6*	PEERI	Lursarea
	- Number of businesses with Integrated Environmental Authorisation (IEA) in flood plain	7*	PEERI	Lursarea
	- % of surface area of garages in relation to surface area exposed to floods	8*		Lursarea
Exposure	- Number of buildings built on a flood plain	11*	PEERI	Lursarea
	- Number of homes located at ground level in flood plains	6*	PEERI	Lursarea
	- Industrial plants in flood plains	214	PEERI	Lursarea
	- Undeveloped land exposed to river flooding	217	PEERI	Lursarea
	- Artificial ground exposed to river flooding	218	PEERI	Lursarea
	- Surface area of developed land in a flood plain	219	PEERI	Lursarea
Impact	Number of flooding events	12*	PEERI	Lursarea
	- Economic cost caused by floods	103*	PEERI	Lursarea
	- Fire brigade interventions required due to "water damage". Average annual interventions (Rate per 1000 inhabitants)	193		Lursarea
Adaptation	- Percentage of surface area that is impermeable	191*	PEERI	Lursarea
	- No. of local organisations with self-protection plans	17*	PEERI	GAN-NIK
	- Percentage of homes in poor condition	51	PEV	Lursarea
	- Surface area (ha) of flood lamination areas (m^2 expanded river space)	18*	PEERI	G.N. (Department for Circular Economy and Water)
	- Surface area (m^2) with sustainable drainage systems	84*		NILSA
	Volume of rainwater retained by SUDS	61	C2.3 action	NILSA

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	- No. of improvements in collectors	16	NILSA

Impact of temperature on the built environment

Table 18. Impact chain relating to the impact of temperature on the built environment

Type	Indicator	Code	Reference	Provider
Climate variable	- No. of days where thermal sensation thresholds are exceeded	197	Meteo GN	Meteo GN
	- Atmospheric dispersal capacity	198		Meteo GN
	No. of tropical nights	46	Meteo GN	Meteo GN
	Average monthly and annual temperature	153	Meteo GN	Meteo GN
	Magnitude, amplitude, number, duration and frequency of heat waves	168	Meteo GN	Meteo GN
Vulnerability	Homes over 40 years old	208	PEV	Lursarea
	Artificial ground	209	SIOTN	Lursarea
	Number of homes per urban area	210	PEV	Lursarea
	Compactness of urban fabric	211	SIOTN	Lursarea
	No. of entities per municipality	212	NASTAT	Lursarea
	Accessibility to primary health care centres	205	SIOTN	Lursarea
	Municipality budget (€/inhabitant)	206	NASTAT	Lursarea
	Year of municipal planning approval	207	SIUN	Lursarea
	Surface area of empty space in relation to urban areas	204	SIOTN	Lursarea
	Surface area of empty space per inhabitant	203	SIOTN	Lursarea
	Percentage of undeveloped land	202	SIOTN	Lursarea
	-% of population aged 65 or over	124	NASTAT	NASTAT
	-% of population aged 15 or less	128	NASTAT	NASTAT
	-% of homes over 40 years old	129	PEV	Lursarea
	- % surface area of green spaces (including forests)	131		Lursarea
	- No. of people over the age of 80 who live alone	73*	PSN	ISPLN, OSCN
	- Energy poverty per CP	133		Lursarea
	- Poverty risk rate per Basic Health Zone	169*	PSN	ISPLN, OSCN
Exposure	- Urban sky view factor.	137		Lursarea
	- Population density per municipality	138	SIOTN	Lursarea

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	- Population per municipality	139	NASTAT	Lursarea
	- Density of urban fabric	141	SIOTN	Lursarea
	- Materials in urban fabric (albedo)	174		Lursarea
Impact	- Average annual concentration of particles (PM10)	178		RVCA
	Heat island effect	91	PEV	Lursarea
	Cooling degree days	222	PEV	Lursarea
	Heating degree days	223	PEV	Lursarea
	- Exterior thermal comfort (street)	196	PEV	Lursarea
	- Interior thermal comfort (home)	181	PEV	Lursarea
Adaptation	- Percentage of surface area that is impermeable	191*	PEERI	Lursarea
	- Percentage of homes in poor condition	51*	PEV	Lursarea
	- Surface area of "cold" roofs and floors	145		Lursarea
	- Number of water sources and/or lakes installed	146		Lursarea
	- Green façades and roofs	147		Lursarea
	- New surface area of green areas with woodland	195	PIV	Lursarea
	- Green/river/safe routes	158	PIV	Lursarea
	- Number of homes with energy rating A/B/C/D	160	PEV	Lursarea
	- Increase in shade	199		Lursarea

Table 19. Impact of climate change on features of the landscape

Type	Indicator	Code	Reference	Provider
Climate variable	Continentality index			Lursarea
	Köppen climate classification	60	Lursarea	Lursarea
	Average monthly and annual temperature	153	Meteo GN	Meteo GN
	ETP		Lursarea	Lursarea
	Total monthly and annual precipitation	1	Meteo GN	Meteo GN
	Rivas-Martinez Aridity Index		Lursarea	Sigmatec
	Bioclimatic zones	86	Lursarea	Sigmatec
Risk (exposure-vulnerability-danger)	Index of risk caused by a change in bioclimatic zone affecting the landscape	132	Lursarea	Sigmatec
	Risk index for landscape mediterraneisation	90	Lursarea	Sigmatec
	Risk index for impact on spaces of ecological and scenic interest	95	Lursarea	Sigmatec
	Risk index for impact on main elements of the forest landscape	99	Lursarea	Sigmatec
	Risk index for impact on main elements of the agricultural landscape	111	Lursarea	Sigmatec
	Climate change risk to forest landscape components	118	Lursarea	Sigmatec
	Overall index for risk to landscape	122	Lursarea	Sigmatec
Impact	Latitudinal displacement of vineyards	47	Lursarea	Lursarea
	Variations in yield of vineyards	134**	ESYRCE, PEAN	Lursarea / INTIA
	Variations in the growing period of forest species	78*	PFN	G.N. (Department for Strategic Planning of the Natural Environment)
	Annual hectares burned by forest fires	54*	EIF	G.N. (Department for the Prevention of Forest Fires)
Adaptation				

** Filtered indicator only for vineyards

Impact of climate change on transport infrastructure

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Table 20. Impact chain relating to the impact of climate change on transport infrastructure

Type	Indicator	Code	Reference	Provider
Climate variable	- Total annual precipitation when RR > 95p (mm)	35*	Meteo GN	Lursarea /Meteo GN
	- Total annual precipitation when RR > 99p (mm)	36*	Meteo GN	Lursarea /Meteo GN
	- Maximum cumulative precipitation in 1 day (mm)	2*	Meteo GN	Lursarea /Meteo GN
	- 95th percentile of daily precipitation (mm)	38*	Meteo GN	Lursarea /Meteo GN
	- No. of days with precipitation in the form of snow	143	Meteo GN	Meteo GN
	- Daily thermal oscillation	68	Meteo GN	Lursarea /Meteo GN
	- Seasonal thermal amplitude	72	Meteo GN	Lursarea /Meteo GN
Vulnerability	- Vulnerability of transport networks	77	PDC	Lursarea (C6.6)
Exposure	- Km of infrastructure in areas at high risk of land slippage	182		Lursarea (C6.6)
	- Kilometres of infrastructure in flood plains	189	PEERI	Lursarea
Impact	- Economic damage caused by land displacement	183	PDC	Lursarea (C6.6)
	- Economic damage caused by landslides	184	PDC	Lursarea (C6.6)
	- Number and location of landslides	185	PDC	Lursarea (C6.6)
	- Economic damage caused by expansion in roads	177		Lursarea (C6.6)
	- km of infrastructure affected by floods each year	192	PEERI	Lursarea (C6.6)
Adaptation	- Reducing the gradient of slopes	186		Lursarea (C6.6)
	- Slope protection (grey infrastructure)	165		Lursarea (C6.6)
	- Reforesting slopes	187		Lursarea (C6.6)
	- Evacuation plans (people)	188		Lursarea (C6.6)
	- Adaptation of evacuation systems in infrastructure	172		Lursarea (C6.6)

- *The majority of indicators relating to this impact chain shall be calculated based on the results of action C6.6, starting in 2022.*

Urban environment: Tourism

To be developed.

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APPENDIX C. DESCRIPTION AND METHODOLOGY FOR CACULATING INDICATORS

During the process of calculating the indicators, metadata was added, including the frequency of calculation, scale, data source and provider etc. Below is a description of the methodology used to calculate each indicator. In some cases, both the data source and methodology have been defined and in other cases they have not yet been defined.

Firstly, there is a description of the strategic adaptation indicators (SA), and then all of the sectoral adaptation Indicators:

INDICATOR AS1. Population in municipalities with mechanisms for adapting to climate change

Total sum of the population living in municipalities with mechanisms for adapting to climate change. The mechanisms considered are the Municipalities' Agreement for Climate and Energy, and the pilot projects for adapting to climate change, EGOKI and EGOKI2.

INDICATOR AS2 Average annual temperature in Navarra

See indicator 153

INDICATOR AS3. Annual precipitation in Navarra

See indicator 1

INDICATOR AS4. Flooding: Damage to property caused by flooding

See indicator 103

INDICATOR AS5. Water resources: Total water consumption per inhabitant

See indicator 31

INDICATOR AS6. Fires: Annual hectares burned by forest fires

See indicator 54

INDICATOR AS7. Health: Hospital intake caused by effects of heat

See indicator 170

INDICATOR AS8. Agriculture: Variations in yield of main crops

See indicator 134

INDICATOR 1. Total monthly and annual precipitation (mm)

Climate variable. All of the climate indices have two clearly differentiated components. On the one hand, there is the series of historical data observed at weather stations. In this case, the provider is the Department for Soil and Climatology at the Government of Navarra. The historical data series relating to daily precipitation at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled

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using interpolation. For the period 1961-2020, data is only shown from stations which covered the entire period.

On the other hand, the data for future climate scenarios is estimated using regional climate models (RCM) and emissions scenarios (RCP8.5). In this case, the data from the AdapteCCa platform will be listed, which includes data by weather station or by grid. In order to show information that is consistent across observed data and estimated future data, and to be able to compare the observed data with the estimated data for each model, it is necessary to make a bias adjustment to the projections.

Without this adjustment, only annual observed data will be shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

This variable corresponds to index 27 **(PRCPTOT)** on the list of indices proposed by the group of experts ETCCDI [4].

Monitoring: Annual

INDICATOR 2. Maximum cumulative precipitation in 1 day (mm)

Climate variable. The maximum amount of rain that falls in one day, in millimetres. This is calculated for manual weather stations. The historical data series relating to daily precipitation at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The maximum annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

This corresponds to index 17 **(Rx1day)** on the list of indices proposed by the group of experts ETCCDI [4].

Monitoring: Annual

INDICATOR 3. Maximum cumulative precipitation in 5 days (mm)

Climate variable. The maximum amount of rain that falls in five consecutive days, in millimetres. This is calculated for manual weather stations. The historical data series relating to daily precipitation at

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each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The maximum annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

This corresponds to index 18 **(Rx5day)** on the list of indices proposed by the group of experts ETCCDI [4].

Monitoring: Annual

INDICATOR 4. Number of days with precipitation ≥ 20 mm

Climate variable. Number of days per year with precipitation of more than 20 millimetres. This is calculated for manual weather stations. The historical data series relating to daily precipitation at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

This corresponds to index 20 **(Rnnmm)** with a lower limit of 20mm set by the user of the list of indices proposed by the group of experts ETCCDI [4].

Monitoring: Annual

INDICATOR 5. No. of sewage treatment plants in flood plains

Exposure indicator. Based on the location of the 190 waste water biological treatment plants assigned in the Master Plan for the Integral Water Cycle for Urban Use in Navarra (available from IDENA), managed by NILSA, the Association for the Region of Pamplona and the Association of Montejurra, and the corresponding surface area of low probability flood plains (T=500 years) defined by MITECO (*) [5], we can find the number of treatment plants located in flood zones associated with a 500-year return period.

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** New flood studies are being carried out and updated, but currently many secondary rivers and streams have not had their flood plains calculated.*

Date of last update: July 2020

Monitoring: Partially static indicator as it practically ended with the construction of new treatment plants. This shall be reviewed and updated every four years.

INDICATOR 6. Number of homes located at ground level in flood plains

Exposure indicator. Based on land parcels, buildings and urban units, we can determined the total number of urban units that correspond to a home at ground level per land parcel. This calculation is only carried out for land parcels which have buildings in flood plains with a low or rare probability of flooding (T=500 YEARS) as defined by MITECO *(* New flood studies are being carried out and updated, but currently many secondary rivers and streams have not had their flood plains calculated).*

In addition, these ground floor homes can be divided up further, depending on whether they are in low, medium or high risk areas, based on which locations are defined as Areas with a Potentially Significant Risk of Flooding (ARPSI), the data for which is available from MITECO [94], obtained from a preliminary assessment of flood risk carried out by the relevant authorities for water, coasts and public safety. However, it must be taken into account that records do not exist for all flood plains, meaning that in some cases it will not be possible to determine the degree of risk allocated to the homes.

Monitoring: Biennial.

INDICATOR 7. Number of premises with Integrated Environmental Authorisation (IEA) in flood plain

Vulnerability indicator. Navarra's environmental regulations (LFIPA) lists the premises or facilities in Navarra that have Integrated Environmental Authorisation (IEA); there are a total of 131 premises. Based on the river flood plains with a low or rare probability of flooding (T=500 YEARS), as defined by MITECO, it is possible to select facilities which are in a flood plain.

Source: Pollution Prevention Division of the Environment Department (IEA) and MITECO (flood plains) [117].

Monitoring: Annual

INDICATOR 8. % of underground surface area (garages) in relation to surface area exposed to floods

Vulnerability indicator. This calculation shows the sum of the surface area corresponding to garages (urban unit → floor = underground / purpose = garage) within flood plains with a low or rare probability of flooding (T=500 YEARS), as defined by MITECO, in relation to the total surface area of the same area.

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Monitoring: Biennial.

INDICATOR 9. Inventory of overflow points for run-off water in sanitation systems

Vulnerability indicator. The proprietors of industrial and urban discharges with a population equivalent of more than 2000, whose sanitation systems cause water overflows during periods of rain, must have presented to the riverbank authorities a record of the overflow points by 31 December 2014. At the moment, only the discharges corresponding to NILSA are listed here. These are filtered into only the overflow points which are produced by rain/storms, and showing the number of overflow points per conurbation.

Monitoring: Every four years.

INDICATOR 10. % of surface area of industrial estates exposed to floods

Exposure indicator. This is calculated using the surface area of industrial estates recorded at IndusLANd (platform for industrial land in Navarra) and the surface area of those located within flood plains with a low or rare probability of flooding (T=500 YEARS), as defined by MITECO, in relation to the total surface area of industrial estates. The calculation can be disaggregated by local entity.

Monitoring: Every four years; urban development is very slow.

INDICATOR 11. Number of buildings built on a flood plain

Exposure indicator. This is calculated using the number of buildings (based on the building demarcations registered with the land registry) which make up each parcel of land located within flood plains with a low or rare probability of flooding (T-500 YEARS), as defined by MITECO. The calculation is disaggregated by municipality.

** Building demarcations correspond to the borders of buildings in Navarra as registered with the land registry. It does not include all constructions. All of the adjacent industrial estates within each land registry parcel have been merged in order to achieve a more accurate representation of the number of buildings.*

Monitoring: Biennial.

INDICATOR 12. Number of flooding events

Impact indicator. The General Directorate for Public Safety has been drawing up the National Catalogue of Historic Floods (CNIH) since 1995, with the aim of standardising and homogenising the collection of data relating to historic floods on a national level, as well as facilitating and ensuring updates to data in the event of any new flooding events. The catalogue has data recorded up to December 2010, so the data series for the years 2010-2019 has been completed based on press reports. The data shows the number of flooding events per decade in Navarra. Data could also be given per municipality. Source: [118]

Monitoring: Decades

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INDICATOR 13. Number of days with frost per month and per year

Climate variable. This corresponds to index 1 (FD) on the list of indices proposed by the group of experts ETCCDI [4], and is already included as a climate variable on the AdapteCCa platform.

FD = Number of days with frost Annual and monthly sum of the number of days in which the minimum temperature is below 0°C.

The annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

An improvement could be to include the monthly data and the number of frost-free days.

Monitoring: Annual

INDICATOR 14. People affected by flooding

Impact indicator. The starting data used here is the flooded surface area (provided by IDENA or obtained via remote detection technology), and by cross-referencing this information with the population data, we can calculate the number of people affected. The population data is obtained based on land registry parcels, the urban units which make these up, and the average number of inhabitants per parcel in each municipality, with this approximation being fairly accurate representation of the real data.

Monitoring: Annual, if data is available.

INDICATOR 15. Surface area flooded (ha)

Impact indicator. The demarcation of areas affected by flooding is provided by IDENA in some cases (e.g. Flooding on 11-14 April 2018) using remote detection technology with satellite images from the Sentinel-1A Radar in the Copernicus programme. Remote detection techniques include calibration, geometric and topographic correction and filtering of data using Speckle filtering. The resolution of the images used is 10 metres. This methodology could be applied in each case to determine the flooded surface area.

Monitoring: Annual, if data is available.

INDICATOR 16. Number of improvements in collectors

Adaptation indicator. Using the NILSA annual action plan and the implementation of a list to be completed at the department of Operations and Maintenance, we can see which improvements have been implemented each year. Improvements are considered to be changes to sewage pipes, manholes etc. In each case, there will be a brief description of what was involved in said improvement.

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The data submitted by NILSA to create this and other indicators consists of the data to which the organisation has access, i.e. regarding sanitation systems within their scope of authority and specifically for systems with a population equivalent of more than 2000. To obtain data from other agencies, it may be possible to contact different associations and administrative bodies, which finance municipal works with PIL.

The networks of underground channels in different municipality associations (Montejurra, Pamplona, Valdizarbe etc.) are available from IDENA to a limited extent. Improvements could be added as a characteristic with a date in order to monitor them.

Monitoring: Updated every two years.

INDICATOR 17. Number of local organisations with self-protection plans

Adaptation indicator. Indicator D2 for monitoring the project, the calculation method for which is the responsibility of Navarra's Environmental Management (GAN-NIK). Municipalities which have local self-protection plans for the event of flooding in local establishments within the scope of the LIFE NAdapta project (action C2.5)

** This indicator is added to the rest of the municipalities which have an emergency flood plan for areas outside the scope of the Life NAdapta project. In the "SPECIAL EMERGENCY PLAN TO PROTECT AGAINST FLOODING IN THE AUTONOMOUS COMMUNITY OF NAVARRA", there are 45 municipalities listed which must have a municipal action plan for the event of flooding, of which 9 already have emergency plans approved in 2018. Source: Department for Circular Economy and Water*

Monitoring: Annual

INDICATOR 18. Surface area of flood lamination areas (m² of expanded river space)

Adaptation indicator. Indicator D2 for monitoring the project, the calculation method for which is the responsibility of Navarra's Environmental Management (GAN-NIK). Data to be obtained based on the execution of river restoration projects (6).

Monitoring: Every four years. These are projects which usually take more than one year.

INDICATOR 19. Surface area of protected spaces according to INSPIRE directive

Adaptation indicator. This is used at IDENA and encompasses the information relating to protected areas, including in the European inventory of nationally designated areas (CDDA) and the spaces included in the Natura 2000 Network. The CDDA comprises natural monuments and the Network of Protected Natural Spaces (RENA), made up of: natural recreational spaces, natural areas, protected landscapes, natural parks, protected reserves and natural reserves. The Natura 2000 Network comprises: Place of Importance for the Community (LIC), Special Conservation Areas (ZEC) and Special Protection Areas for Birds (ZEPA). The indicator calculates the total surface area of protected places in hectares. The areas covered by more than one protective title are only counted once.

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Monitoring: Annual, if data is available.

INDICATOR 20. Concentration of allergenic fungal spores in the atmosphere

Exposure indicator. This corresponds to one of the indicators listed in the document "Indicators for Health and Climate change 2016", approved by the Commission for Public Health at the Inter-territorial Council for the National Health System [69]. The daily atmospheric concentration of potentially allergenic Alternaria fungus spores allows us to document changes over time in places where sampling stations are located.

The starting data includes daily and monthly pollen reports by the Government of Navarra for the Pamplona station, and recently also in Tudela, and daily concentrations are monitored along with the monthly average and the number of days where a threshold is exceeded (high or very high figure > 50 grains/m^3).

Monitoring: Annual

INDICATOR 21. Standardised Drought-Precipitation Index (IESP)

Climate variable. The method for calculating this index is explained by the Office for Environment and Land Planning in the Regional Government of Andalucia [7]. The IESP consists of standardising monthly cumulative rainfall anomalies, allowing us to differentiate the dry and wet periods on a monthly basis, as well as the intensity and duration of these periods.

The starting information corresponds to the geographic information regarding the distribution of precipitation each month. This information is drawn up based on data from weather stations belonging to the State Meteorology Agency (AEMET) and the Office for Agriculture, Fishing and Environment. The IESP [8] is calculated in three sequential steps:

- Calculation of rainfall anomalies for each of the months in the series.
- Calculation of cumulative rainfall anomalies, from the first month of the series. If a negative cumulative anomaly is found, this will initiate a dry period, which will then be concluded when a positive cumulative anomaly occurs, giving rise to an excessive wet period; during this excess period, the anomalies continue to accumulate until a negative rainfall anomaly occurs again, at which point a new dry period will be initiated, which is determined using the same method, with the cumulative calculations restarting based on this negative rainfall anomaly value.
- Standardisation of cumulative anomalies using conversion to Z scores.

Monitoring: Only calculated in Navarra if there is a prolonged period of drought.

INDICATOR 22. Number of consecutive dry days (RR < 1 mm)

Climate variable. Number of consecutive days with no precipitation or with precipitation less than 1 millimetre. This is calculated for manual weather stations for the period 1961-2020. The historical data series relating to daily precipitation at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried

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out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The maximum annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

This corresponds to index 23 (CDD) on the list of indices proposed by the group of experts ETCCDI [4] and ADAPTECCA index P5 [9].

Monitoring: Updated in 2020

INDICATOR 23. Number of visits to companies to analyse the exposure of the working population to extreme temperatures

Adaptation measure. The Occupational Health Service of the Institute of Public and Labour Health of Navarre (ISPLN), through the Occupational Health Service, has visited more than 200 companies since 2019, as part of the campaign "Exposure of the working population to extreme temperatures", whose main objective is to know how the risk of discomfort and heat stress in the workplace is identified, assessed and managed, whether due to exposure to heat or cold.

The campaign is part of the actions developed in the health area of LIFE-IP NAdapta-CC, a project that includes measures for the adaptation of Navarre to climate change. Specifically, this initiative is the Monitoring of working conditions and consequences of climate change; extreme temperatures on the health of workers. This indicator includes both the number of companies visited and the number of workers in these companies.

Monitoring: Annual (action completed in 2021)

INDICATOR 24. Drought (Precipitation deciles < 30)

Climate variable. Precipitation deciles divide the distribution of cumulative precipitation for a certain time scale into 10 categories, with an approximately even probability of occurrence, using the data series for precipitation at each station in the selected period (1961-1990) as a reference [14].

Monitoring: Annual

INDICATOR 25. Intensity of precipitation

Climate variable. 13 automatic weather stations with a 20 years or more have been selected and, based on the hourly data of the whole series, we can calculate the annual figures for maximum precipitation in one hour. It is worth highlighting that because the starting data is in the form of hourly figures, and not ten-minute intervals, the figures for an extreme precipitation event that occurs for a period of one hour (e.g. from 8:30 to 9:30) may be recorded as split across two consecutive hours.

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Only data from years with a minimum of 300 days of records are shown, and the annual data is accompanied by the trend line, divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

Utility index for impact chain relating to floods and extreme precipitation.

Monitoring: Annual

INDICATOR 26. Mortality attributable to temperature excesses

Impact indicator. The MoMo model, managed by the National Epidemiology Centre (CNE) of the Carlos III Health Institute, aims to identify deviations of observed daily mortality from that expected according to historical mortality series and to report significant mortality deviations to the Ministry of Health for investigation or for the implementation of appropriate control measures. The indicator describes the effects of excess temperatures on mortality in Navarra during the period from 1 June to 15 September for each year from 2018 onwards.

The results have been obtained using the new MoMo model, which in addition to estimating excess mortality from all causes, also estimates excess mortality attributable to temperature deviations, both due to heat and cold and throughout the year.

Monitoring: Annual

INDICATOR 27. Variation in availability of water resources

Impact indicator. The phoronomic network managed by the Government of Navarra consists of 23 gauging stations which, when added to the 27 managed by the Ebro Water Confederation, makes a total of 50 gauging stations. At [16], it is possible to obtain daily, hourly and by-the-minute data regarding river levels and flow rates, among other variables, for each station. Based on this data, an estimation can be made of the water resources measured at these 50 stations and any variations can be monitored annually.

This indicator would require a study in advance, to enable the selection of gauging stations at which the climate may be more of a key factor than other, non-climate-related factors (changes in soil usage, reservoirs etc.).

Monitoring: Annual Future prediction based on climate scenarios.

INDICATOR 28. No. of accidents in the workplace recorded at DELTA relating to exposure to high temperatures

Impact indicator. The Electronic Reporting System for Accidents in the Workplace (Delt@) lists all of the accidents in the workplace that have been recorded, including the codification of the variables

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relating to the causes and circumstances of the accident. Based on this source data, we can monitor the number of accidents per year with a caused relating to exposure to high temperatures.

Source: Institute for Public and Occupational Health in Navarra. Department for Occupational Health and Safety. Department for Monitoring Health in the Workplace.

Monitoring: Annual

INDICATOR 29. No. of municipalities where *Aedes Albopictus* mosquitoes have been detected

Exposure indicator. Indicator included in "Indicators for Health and Climate Change 2016" [69]. Based on a count of the number of municipalities in which the presence or establishment of the *Aedes albopictus* mosquito has been identified.

- **Formula:** The sum of all municipalities in which the presence or establishment of a vector has been declared in the year of reference.

- **Objectives:** To have information available relating to the propagation of the vector, and to identify the territories in which the vector has become established. This will allow variations to be detected in municipalities with a theoretically higher risk of diseases being transmitted by *Aedes albopictus*.

- **Limitations:** Data is only available from certain municipalities. The presence of a vector does not mean that it carries the micro-organism which causes disease in humans. The indicator refers to the number of municipalities in which searches resulted in positive findings of eggs (which does not mean that the presence of an adult mosquito has been identified).

- **Utility of indicator:** To follow the trend over time and space, enabling people to prepare and respond in the territories identified.

- **Source:** Autonomous Communities (monitored by the Sub-Directorate General of Environmental Health and Occupational Health and Safety / DGSPCI. MSSSI)

Monitoring: Annual

INDICATOR 30. Indicator for hydrological drought status

Climate variable. The indicators for Prolonged Drought give an objective evaluation of whether the Territorial Units of Drought (UTS) defined in the Special Plans for Drought (PES) find themselves in a situation of Prolonged Drought or not, in terms of the standards set out. This situation shows a

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significant reduction in the flow rates in bodies of water, a natural consequence of reducing precipitation, regardless of the uses and demands of existing water. Therefore, the indicators used correspond to precipitation or inflow in a quasi-natural framework. Based on the monthly monitoring maps of the indicator for hydrological drought status per UTS for each water basin, available every month since 1958/59 or 1980/81 (according to UTS), the development of the status in each UTS is monitored:

Sources: Ebro Water Confederation and Cantabria Water Confederation [119]

Monitoring: Annual

INDICATOR 31. Total water consumption per inhabitant (litres/inhabitant/day)

Adaptation indicator. Certain effects of climate change, such as persistent droughts, along with other factors such as population growth, urbanisation and pollution, are putting increasing pressure on the supply and quality of water in Navarra.

Navarran citizens use huge amounts of water each year, not just for human consumption, but also to meet the needs of the agriculture, manufacturing, heating, cooling and tourism sectors, as well as other sectors and services.

A reduction in water consumption per inhabitant is considered to be a good adaptation measure to tackle a possible reduction in the availability and quality of water resources in Navarra due to climate change.

The calculations of current consumption per municipality are listed in the Master Plan for the Integral Water Cycle for Urban Use in Navarra 2019-2030 [89] have been carried out taking into account the average consumption between 2011-2015, in places where data has been provided, and based on estimates in areas where data was not recorded or was of questionable quality. Based on the consumption and population data, the indicator shows the average provision in litres per inhabitant, per day, both in total and for domestic use. Except in a few cases, municipalities with a provision level of more than 600 l/inhabitant/day are associated with higher levels of unregistered water (ANR) and/or high levels of industrial consumption.

A negative trend is expected in this indicator, with a reduction in water consumption being achieved through a series of best practices.

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Data source: Surveys at local businesses and industries, and estimates.

Monitoring: Annual

INDICATOR 32. Number of regional plans adopted after an evaluation of water resources based on climate change scenarios and patterns of usage and demand

Adaptation indicator. Indicator D2 for monitoring the project, the calculation method for which is the responsibility of Navarra's Environmental Management (GAN-NIK).

Monitoring: Annual

INDICATOR 33. Loss of water in distribution networks (increase in efficiency)

Adaptation indicator. Depending on the availability of data (municipality associations, Department for Circular Economy and Water at the Government of Navarra), the quantity of non-revenue water (ANF) in the distribution networks can be calculated in accordance with the directives of [19]. Ideally, this data could be disaggregated by local business or entity.

Monitoring: Annual

INDICATOR 34. Usage and consumption index

Adaptation indicator. This includes two indicators for the MAPAMA System of Water Indicators [21] which show the intensity of the use of water resources: The exploitation index, which is the relationship between water demand and natural water resources; and the consumption index, which is the relationship between consumptive water demand and natural water resources. The first is considered to be the gross water demand, i.e. the amount it is necessary to take from the environment in order to satisfy the water demands for various uses, and the second is considered to be the consumptive demand, which is the amount truly consumed when water is used. The difference between the two is whether the water being produced is returned to the environment, and this depends on the type of use and the efficiency of the water usage.

The estimated levels of demand require complex analysis; the values used come from an estimation made for each former planning area during the process of drawing up the water basin plans by the Centre of Studies and Experimentation with Public Works (CEDEX). The value of the natural water resources is obtained using the SIMPA hydrology model, developed by CEDEX; the values provided by the model for each one km^2 cell in which the national territory has been discretized, has been aggregated to the same scale as the demand levels.

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In the same way as the procedure used on a national level, it is possible to calculate the annual value of these indices for the territory of Navarra. In terms of data source, it would be necessary to gather information from the irrigation advisory services and AGROgestor.

Monitoring Annual, by sector.

INDICATOR 35. R95pTOT. Total annual precipitation when RR > 95p (mm)

Climate variable. This corresponds to index 25 (R95pTOT) on the list of indices proposed by the group of experts ETCCDI [4] and one of the ADAPTECCA climate indices [9]. This is defined as the total precipitation when RR > 95p.

$$R95p_j = \sum_{w=1}^{W} RR_{wj} \; donde \; RR_{wj} > RR_{wn}95$$

Where RR_{wj} is the daily precipitation on a rainy day w ($RR \geq 1.0$mm) in the period I and RR_{wn95} is the 95th percentile of precipitation on rainy days in the reference period (1961-1990). W represents the number of rainy days in the given period. Calculated for the historical data from manual weather stations.

Monitoring: Annual

INDICATOR 36. R99pTOT. Total annual precipitation when RR > 99p (mm)

Climate variable. This corresponds to index 26 (R99pTOT) on the list of indices proposed by the group of experts ETCCDI [4] and one of the ADAPTECCA climate indices [9]. This is defined as the total precipitation when RR > 99p.

$$R99p_j = \sum_{w=1}^{W} RR_{wj} \; donde \; RR_{wj} > RR_{wn}99$$

Where RR_{wj} is the daily precipitation on a rainy day w ($RR \geq 1.0$mm) in the period I and RR_{wn99} is the 99th percentile of precipitation on rainy days in the reference period (1961-1990). W represents the number of rainy days in the given period. Calculated for the historical data from manual weather stations.

Monitoring: Annual

INDICATOR 37. No. of people with chronic respiratory illness

Vulnerability indicator. A good indicator for measuring the vulnerability of each municipality or healthcare area in the face of deteriorating air quality caused by climate change (among other

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factors) is the number of people with chronic respiratory illnesses, who are especially vulnerable to said deterioration in air quality.

Monitoring: Annual

INDICATOR 38. 95th percentile of daily precipitation (mm)

Climate variable. Corresponds to one of the climate indices of ADAPTECCA [9]. Based on daily precipitation data, we can calculate the precipitation level corresponding to the 95th percentile.

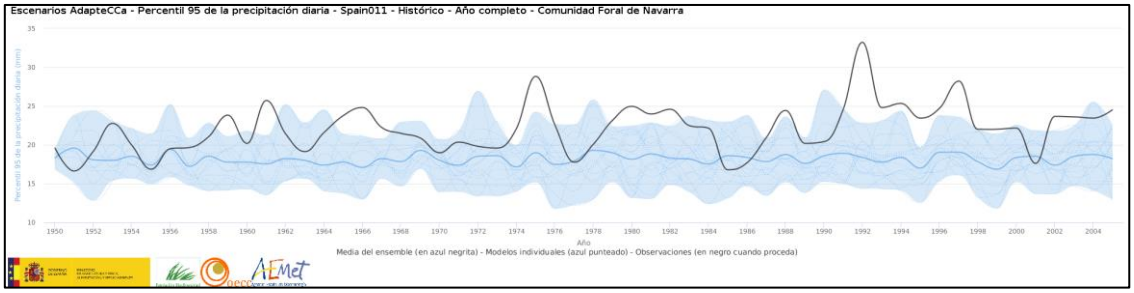


Figure 4. Source: AdapteCCa platform. View climate scenarios

Calculated for the historical data from manual weather stations.

Monitoring: Annual

INDICATOR 39. Treatment plants with problems caused by rainwater.

Vulnerability indicator. In Appendix IC of the Master Plan for the water cycle for urban use, a study has been completed of the condition of sanitation networks to select plants that should be considered as a priority, based on a multi-criteria analysis which weighed up various aspects of these plants: electrical consumption, sensitivity of the riverbed, previously conducted studies and more. The following plan shall establish new priority sewage treatment plants.

To calculate the priority index, the following criteria have been used:

Population equivalent range

Range	Priority index
Less than 250 he.	1
Between 250 and 2000 he.	5

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Between 2000 and 15000 he.	10
More than 15000 he.	15

Knowledge or ease of action

Knowledge	Priority index
There is no prior information about the origin of parasitic water	1
This is some prior information, or some specific actions are known	5
There is prior information, validated reports, studies etc.	7
There are specific projects relating to specific actions	10

Risk of non-compliance with discharge permit due to parasites or rainfall

Risk of non-compliance with discharge permit	Priority index
The incorporation of parasitic water does not entail a risk of non-compliance with the discharge permit (AV)	1
There may occasionally be non-compliance with the AV	5
There is a sustained risk of non-compliance with one of the parameters of the AV	7
The is no compliance with the AV	10

Basin priority

Rivers	Priority index
Rivers: Ebro, Aragón, Bidasoa	1
Rivers: Pyrenean rivers, Salado river	5
Rivers: Urederra, Ega, Barrancos, Acequias, Erro	7
Rivers: Arakil, Arga, Larraun, Zidacos, Pantanos and areas of Baño, Alhama, Queiles and Huecha	10

Other ratios to consider:

- Ratio m^3 treated per m^3 inhabitant at 150/l. day

- m^3 per inhabitant equivalent

- kwh per inhabitant year

Monitoring: Partially static indicator associated with the Plan, to be finalised in 2030.

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INDICATOR 40. Sewage treatment plants with storm water regulation systems

Adaptation indicator. NILSA analyses the treatment plants that have infrastructure to prevent water being released in the event of a storm.

Rainwater management, often in combined network systems, has made it necessary to build regulation and storage systems, known as storm tanks. These facilities store mixed water (waste water and rain) that comes from the networks during periods of rain, gradually incorporating it into the treatment plant, thus preventing the water from being released and ensuring the treatment plant is able to treat a higher volume of water. For treatment plants which have storm water regulation systems, it shows the volume of water that can be stored in the collector due to its large diameter and low gradient *(in line)* and the tank, if there is one. If there is an in line and tank, this is because there is a type of storm tank and a possibility of the water level rising in the collector, being stored before being treated by the treatment system.

Monitoring: Partially static indicator as it practically ended with the construction of new treatment plants. This will be reviewed and updated every 4 years for the possible implementation of improvements.

INDICATOR 41. Incidences of overflow in sanitation systems

Impact indicator. It must be taken into account that, during periods of rain of a certain intensity, the capacity of collectors and sewage pipes can be compromised and fairly often, leaks or overflows can occur in rivers when the carrying capacity of the collectors is exceeded. The volume of water released or overflowing is not yet known, although action is beginning to be taken to find out this information.

Royal Decree 1290/2012 states that the proprietors of industrial and urban discharges with a population equivalent of more than 2000, whose sanitation systems cause water overflows during periods of rain, must have presented to the riverbank authorities a record of the overflow points, and the riverbank authorities must have an updated inventory of overflow points for run-off water in sanitation systems, on a conveniently georeferenced computer system. The current PDCIAUU [89] incorporates the obligations arising from said Royal Decree 1290/2012, which specifies that in conurbations with a population equivalent of more than 50,000:

- Arazuri: Pamplona and surrounding areas (MCP)
- Tudela: Tudela, Murchante, Cascante, Fontellas.
- Estella: Estella and surrounding areas (Municipality Association of Montejurra)
- Lower Ebro: Cabanillas, Fustiñana, Ribaforada, Buñuel and Ablitas.
- Lower Ega: Carcar, Andosilla and San Adrián
- Lower Arga: Falces, Peralta, Funes, Caparroso and Marcilla.

The scope of application is limited to discharges in urban conurbations with a population equivalent of more than 50000, industrial facilities of an AA of more than 2000 population equivalent in protected areas of the hydrographic demarcations. NILSA shall provide the treatment plant data, which it manages directly. There are other overflow points, both within the networks managed by NILSA and in those managed by other organisations.

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Monitoring: Updated every two years from 2020 onwards.

INDICATOR 42. Potential vulnerability of forest areas in the face of climate change

Vulnerability indicator. The potential vulnerability of forest areas in the face of climate change has been divided into categories based on the areas of the Spanish Forest Map, according to their potential vulnerability to climate change, estimated based on the index for the sensitivity of forest species (Felicísimo et al. 2011), the average thermal and ombrothermic indices of each area and the predicted changes to said bioclimatic indices, according to regional climate change projections from AEMET under an intermediate scenario (RCP4.5) (link to IDENA).

Monitoring: Only done once

INDICATOR 43. Improvements in sewage treatment plants with major problems caused by rain water

Adaptation indicator. In the PDCIAUU there are plans for investment in new works, in the recovery fund and for extraordinary repairs made depending on the priority index for each sewage treatment plant (indicator 39).

Monitoring: Updated every 2 years.

INDICATOR 44. Average water temperature

Climate variable. One of the effects of climate change that has been observed is the increase in the surface temperature of water, which in turn generates a series of impacts such as a reduction in dissolved oxygen content or a higher amount of algal bloom. The greater the increase in water temperature, the higher the percentage of individuals affected by this heating, and the higher the number of families in dangerous or critical situations [102].

In Navarra, based on the Annual Report of the Automated Network of Water Quality (SAICA Navarra), the average annual temperature has been monitored at 8 stations since 2010 [22]. In addition, the indicator is shown for the percentage of samples per year according to temperature (°C), extracted from the Report of the Water Quality Control Network [115]. The samples are grouped into 4 categories (<18°C, 18-21.5, 21.5-28 and >28°C) as a result of the Directive 2006/44/EC (fishing areas) which, for cyprinid waters and as an imperative parameter, sets a maximum value of 28°C. For salmonid waters, the limit is 21.5°C.

Monitoring: Annual

INDICATOR 45. Surface area of irrigated agriculture

Exposure indicator. The loss of quality in surface waters has an effect on the whole population, but especially on irrigated crops which depend on this water for irrigation. The data source is the Office of Statistics (Department for Rural Development, Environment and Local Administration) based on SIGPAC [95], and is updated annually.

Monitoring: Annual Retrospectively from whenever data is available.

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INDICATOR 46. Number of tropical nights per year

Climate variable. Number of days per year in which the minimum temperature exceeds 20°C. This is calculated for manual weather stations. The historical data series relating to daily minimum temperature at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The maximum annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

Monitoring: Annual

INDICATOR 47. Latitudinal displacement of vineyards

Impact indicator. The majority of current studies predict that climate change will have a significant effect on the countryside. The higher probability of extreme weather events, the general increase in temperatures and the problems with water availability in the face of increasing droughts will have significant negative consequences on agricultural production, both quantitatively and qualitatively.

The effects of climate change on vineyards in the Roadmap for Climate Change in Navarra includes the fact that, as a result of increasing temperatures and drought conditions, it is probable that the area of vine distribution will increase, displacing towards the north. However, there will be other areas where there is an increase in aridity (especially in the southern half of the Autonomous Community), and in these areas, some of the vine crops will no longer be viable or, in other cases, if they want to be maintained, they must be irrigated.

In order to monitor this specific impact, SIGPAC has been used as a cartographic source for the years 2003 to 2020. A filter is run to show the land registry parcels used for vineyards each year and the latitude of the centroid formed by all of the parcels is calculated, in order to monitor the possible latitudinal displacement of vineyards. The results show an average displacement of vineyards towards the north, in line with previous studies [116], by 650 metres between 2003 and 2020. This indicator is accompanied by the altitudinal displacement values, the evolution of the surface area of vineyards and a map of the current and future risk level of vineyards based on the analysis carried out as part of action C6.1 of the LIFE-IP-NAdapta-CC project.

INDICATOR 48. Investment in water quality

Adaptation indicator. The System of Water Indicators (SIA) shows the budget, in millions of euros, which the Ministry of Environment, Rural and Marine Environments has allocated to the Water Quality

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programme, including purification and management in the public water domain. This indicator can be transferred to Navarra based on the items designed for this purpose in the annual budget.

Monitoring: In principle, this will not be calculated.

INDICATOR 49. Percentage of days with a high, very high or extreme meteorological risk

Climate variable. AEMET provides a daily Excel spreadsheet showing the minimum, average and maximum meteorological risk of forest fires per municipality. Forest fire risk levels are generated automatically based on meteorological data and numerical weather prediction models, and they are divided into 5 categories (low, moderate, high, very high and extreme); these are indicators of the probability of a fire, as well as the extent and intensity of the fire.

This table sets this indicator as a percentage of the days in which the maximum meteorological risk was rated as high, very high or extreme in each municipality, and this is monitored monthly and annually.

The daily level of meteorological risk of forest fires is based on the Canadian system and is calculated using the data from AEMET weather stations and the outcomes of a numerical weather prediction model [96]. The input variables for the risk estimation model are: dry air temperature T (°C), relative humidity in the air *Hr* (%), wind speed *Vv* (km/h) and precipitation recorded in the last 24 hours *Pp* (mm). The analysis and prognostic data refer to the 12 UTCs, with the aim of determining the maximum daily risk value, which occurs around midday, although its value is valid for several hours before until several hours after for the 12 UTCs. At AEMET, the data involved in the calculation for risk levels comes from its network of synoptic and automatic weather stations, and the HIRLAM 0.05 model (spatial resolution of 0.05° and an operating window of 47,367 grid points). Each grid point is located in the centre of a square or pixel of 5km on each side, and therefore the calculation variables are representative for an area of 25 km^2 or 2500 ha.

Monitoring: Monthly and annually, per municipality

INDICATOR 50. Rate of danger and importance of protection against fires

Vulnerability indicator. An index calculated using the work on "Risk analysis of forest fires in the Autonomous Community of Navarra" carried out by the company Tecnosylva in 2012. This analysis work involved the development of an integration model for potential risk, the importance of protection and difficulties in extinguishing fires, and it established the following priority defence categories:

- Category I: areas of high danger and high importance
- Category II: areas of high danger and low importance
- Category III: areas of low danger and high importance
- Category IV: areas of low danger and low importance

This division of zones excludes urban town centres given that a fire which develops here cannot be categorised as a forest fire.

Based on said categories, an average rate of danger and importance of protection is calculated (from 1 to 4) at a municipal level, based on the surface area of each zone and the following classifications.

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- Category I → 4 points
- Category II → 3 points
- Category III → 2 points
- Category IV → 1 points

In addition, it gives the percentage of the municipality's surface area registered as having a high danger risk (categories I and II).

Monitoring: Fixed picture (2012). This will not be monitored.

INDICATOR 51. Percentage of homes in poor condition

Adaptation indicator. One effective adaptation measure, both against the progressive increase in temperatures and against the threat of intensive rain and flooding, is improving the condition of buildings. This indicator monitors the number (and percentage) of homes in a poor state of repair. It is calculated based on the grading of the state of repair of an urban unit defined as a home, and a surface area of more than 35 m², the source for which is the Navarra land registry. A positive change in the indicator (fewer homes in poor conditions) would indicate a successful adaptation to the aforementioned climate threats.

Table 21. State of repair figures for urban units. Source: Land registry

Description	Code
Buildings which do not require any major repairs, however old they may be	1.00
Buildings which require some repair work	0.95
Buildings which require occasional major improvements or an average amount of refurbishment	0.90
Buildings which require complete refurbishment due to being unfit for purpose, but which do not have any major structural problems.	0.80
Buildings which require complete refurbishment due to major structural problems.	0.50
Buildings which only consist of exterior walls, provided that the height of these exceeds 1.5 m around its entire perimeter, and buildings to be knocked down in accordance with standard 36.	0.00

Homes are considered to be in poor condition if the state of repair code is 0.00, 0.50 or 0.80 (see table 21).

INDICATOR 52. % surface area of managed forests

Adaptation indicator. The percentage surface area of managed forests is a good indicator of adaptation to climate change, and specifically in the fight against forest fires, provided that the management of the forests includes fire prevention methods.

The surface area of forests is updated annually by SIGPAC (forest use, pasture with woodland, pasture with shrubs and grasslands). On the other hand, IDENA includes information about forest management up to November 2017. Based on these two sources, we can determine the percentage surface area of managed forests per municipality compared to the total forest surface area in the municipality.

As specified in the Report on the Status of the Environment [53], this indicator can be shown separately for forests belonging to local businesses or entities (80% of the surface area of managed forests according to the aforementioned report), privately owned forests (7%) and forests belonging

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to the Government of Navarra (64%). We can see an increase in the surface area of managed forests as an adaptation measure, or the surface area of unmanaged forests as a vulnerable area at high risk of fires. The body responsible for monitoring this indicator will be the future Office for Planning and Programming in the Natural Environment (NPMN). When cross-referenced with the map of properties, this can be broken down by forest species.

Monitoring: Annual

INDICATOR 53. Rainfall erosivity

Climate variable. The main characteristics of precipitation, which causes soil erosion, are total volume (mm), intensity (mm/h--day) and distribution (daily--monthly--annual). In 1978, Arnoldus established the Modified Fournier Index (MFI) which takes into account not just monthly precipitation from the wettest months, but also the rest of the year.

Table 22. MFI values. Source: Arnoldus (1978)

º	Erosivity
>160	Very high
120-160	High
90-120	Average
60-90	Low
<60	Very low

On a European level, data has already been calculated [55] based on the ESDAC database and the rain erosivity database (REDSES).

Monitoring: In principle, this will not be calculated.

INDICATOR 54. Annual hectares burned by forest fires

Impact indicator. The data source for this indicator is the National Forest Fires Database (EGIF), with data from 1985 to 2021 (with no data or no data disaggregated by municipality in the period 1991-2001). Data is added regarding the fires and includes the surface area burned (wooded forest area, non-wooded and non-forest), cause of fire (if it has been possible to determine this) and municipality. In recent years, the municipal council has also been included in many cases, and in some cases even specific coordinates. Based on this data source, we can easily calculate the total surface area burned in Navarra. The web map shows the surface area burned per municipality, as was done in [24], but on an annual basis.

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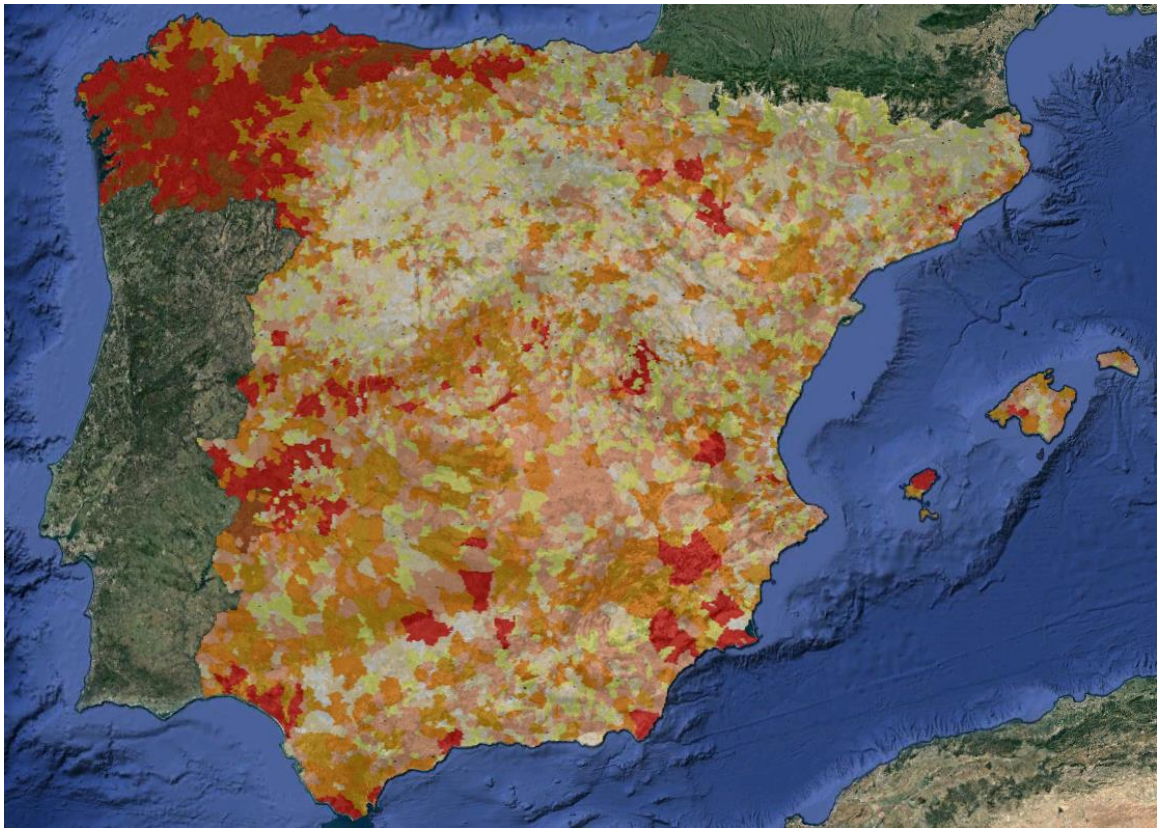


Figure 5. General Forest Fire Statistics (EGIF) per municipality for the period 2001-2014.

Monitoring: Annual, per municipality This could be done retrospectively if data is available.

INDICATOR 55. Number of water fire extinguisher points

Adaptation indicator. Based on the "Safety resources. Accessible water points for aerial fire-fighting" [97] and its updates, we can monitor the number of water points, and any increases in these points as a measure for adapting to the growing risk of forest fires due to climate change. It would be interesting to filter down to just the water points that are easily accessible for aerial fire-fighting resources, disregarding those covered by excess vegetation or with not enough depth, making them unsuitable for this purpose.

Monitoring: Annual

INDICATOR 56. Surface area subjected to clearing or cleaning

Adaptation indicator. This makes it easy to monitor the data for Navarra regarding the surface area (ha) subjected to clearing or cleaning actions as a forest fire prevention measure.

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The information source for this indicator is the forest relief work managed by the Office for Strategic Planning in the Natural Environment.

Monitoring: Annual

INDICATOR 57. Surface area of forest containing critical points for forest fires

Adaptation indicator. Based on the D2 project monitoring indicator *"Forest land under CC vulnerability guidelines (forest fire risk) (ha)"*, the calculation methodology for which is the responsibility of the Department for the Natural Environment (Government of Navarra) and Navarra Environmental Management (GAN-NIK).

The aim is for all forest management plans carried out from now on to include the identification of critical points for forest fires, and to include a section for identifying areas vulnerable to climate change.

Monitoring: Annual

INDICATOR 58. Economic cost caused by hail

Impact indicator. There is not enough information on how extreme weather phenomena can change on a very small scale (such as storms, tornadoes, hail, hail storms and lightning) due to inconsistencies in the recording of these events [76]. An interesting indicator to look at could be the economic cost caused by hail in agricultural areas each year. The data source for this could be Agroseguro or the Government of Navarra. This could be addressed outside of the scope of NAdapta, as part of the insurance/finance sector of PNACC [3].

Monitoring: In principle, this will not be calculated.

INDICATOR 59. Surface area occupied by forest varieties that are vulnerable to climate change

Vulnerability indicator. The key to developing this indicator is to define the species vulnerable to climate change (mainly due to increasing temperatures), based on existing references, own experience or the presence of forest species outside of their normal area of distribution. One very interesting approach to defining the vulnerability of flora and vegetation species is the monitoring in [59] based on the changes in potential distribution areas of different species in a future climate. A similar study in Navarra would make it possible to quantitatively define the most vulnerable species based on the potential percentage loss of surface area, monitor its distribution and define the priority zones for action.

Once these species have been defined, it will be possible to monitor their distribution based on existing maps, such as the Forest Map (MAPAMA), the 4th National Forest Inventory (MAPAMA) or the Map of Crops and Utilisation (IDENA). It does not make sense to review this annually.

In this field of study, the following references [26, 27, 91, 92] may be of interest. In [26], it is mentioned that "the populations with a southern boundary in the upper parts of the mountain ranges will be most affected. Particularly if they coexist with more thermophilic species, or if they have a

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reduced genetic variability". [91] lists the following elements, among others, which are vulnerable to climate change:

- Habitats and species at the altitudinal border of distribution (forests and subalpine grasslands, habitats above the forest line, etc.)
- Relict formations linked to wet or cold conditions
- Forests at the edge of their distribution border (*Quercus ilex* and *Quercus rotundifolia* holm oaks, south Mediterranean pine forests with endemic black pines, etc.)

Monitoring: Initial situation, and ideally monitored annually if there are any changes.

INDICATOR 60. Köppen climate classification

Climate variable. The Köppen climate classification identifies each type of climate with a series of letters indicating the behaviour of temperature and precipitation which characterise each of said types of climate. Under action C6.2, and as part of the climate variability study in Navarra, the Köppen classification map has been established for the periods 1961-1990 and 1991-2019 (interpolation based on observed data at weather stations) and 2021-2050 and 2051-2080 (grid projections for a model associated with an emissions scenario of RCP8.5). Based on the information from the Köppen classification and other climate indices used for action C6.2, we can conclude that there is displacement towards the north under Mediterranean climate conditions, but also in Atlantic and alpine biogeographical regions.

INDICATOR 61. Volume of rainwater retained by SUDS

Medida de adaptación. In action C2.3, monitoring of precipitation events, retained volume, and network reliefs is being carried out in the SUDS of the UPNA of Tudela. This monitoring makes it possible to quantify the positive effect of the SUDS to laminate the runoff generated and minimize the impacts on the downstream unitary network.

Monitoring: Annual

INDICATOR 62. Kilometres of ecological corridors

Adaptation indicator. The network of livestock routes in Navarra is estimated to be 2,139 km long and consists of ecological corridors, ensuring migration, geographical distribution and genetic exchange in wild species. This can be downloaded from IDENA [98] and updated annually. Apart from this, it remains to be seen whether there is a register of ecological corridors that we can monitor. The only references found in this regard are the "*Study for the establishment of a network of biological corridors. Government of Navarra*" (1998) [34] and the Autonomous Decree 230/1998 which cites a study of flora and fauna, and an assessment of vegetation and uses with regards to their inclusion in a network of biological corridors in Navarra.

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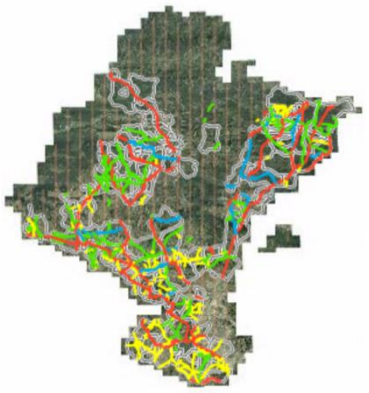


Figure 6. IDENA data on livestock routes

A link could be made between the concept of green routes and/or green infrastructure. Along these lines, the EGOKI project in the municipality of Noain has proposed building a network of green routes (pathways with linear plantations of plants, trees and shrubs), which would improve biodiversity, increase resistance to pest infestations, improve water courses, improve crop yields and create better pathways. This measure could be extrapolated and applied to the rest of the region and, using a record of the projects carried out, monitor the kilometres of green routes that are created.

Monitoring: Annually, if there are any changes. Just livestock routes is not sufficient.

INDICATOR 63. Total investment (€) in special conservation areas

Adaptation indicator. Indicator based on the GIZ Repository of Adaptation Indicators [19]. This gives the total sum of the budget assigned to special conservation areas / the Natura 2000 network.

This is partial data, given that there is a lack of direct investment from the Department for Rural Development and the Environment.

The information source for this is the forest relief work managed by the Office for Strategic Planning in the Natural Environment.

Monitoring: Annual

INDICATOR 64. Percentage of separate sanitation networks

Adaptation indicator. Sanitation networks can be combined (including both waste water and rainwater discharges) or separate. In the case of separate networks, we have pipelines that transport waste water on the one hand, which enters the sanitation system at a low level, and on the other hand we have the rainwater network. Currently, most of the networks are combined with a mixture of both inflows, meaning it is necessary for the total volume to be treated, when this is not necessary for the rainwater. It would be interesting to set up an indicator for separate networks, but this corresponds to sanitation at low level, which is not NILSA's area of responsibility. The responsible party is still to be defined.

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As a possible data source, it is worth highlighting that according to the Master Plan, in section 5.1 Lines of action for strengthening the integral water cycle, it states that *"local competent bodies [or bodies appointed by other] shall carry out a comprehensive inspection of existing infrastructure, for which they shall draw up [or contribute to the creation of] a catalogue with a sufficiently detailed GIS map. The majority of this mapping must be completed by 2020 for management bodies with more than 10,000 inhabitants, and by 2024 for the rest."*

Monitoring: In principle, this will not be calculated.

INDICATOR 65. % of native varieties produced out of the total in regional forest nurseries

Adaptation indicator. The D2 project monitoring indicator *"Number of Autochthonous species [with C3.2 criteria] in regional plants nurseries"*. Action C3.2 refers to the selection of native seeds which have adapted to the environment. The indicator refers to the sales data of the only forest plant nursery registered in Navarra. The percentage is obtained based on the total number of kilograms of seeds or number of native and non-native plants sold.

Monitoring: Annual

INDICATOR 66. Surface area of agriculture vulnerable to erosion

Vulnerability indicator. On the one hand, this will determine vulnerability to erosion using soil indicators [Low = High WHC [deep, loose-textured, not rocky], medium = medium WHC [not very deep, good texture, not very rocky] and high = low WHC [not very deep, rocky, sandy]. The data source for this mapping could be the Map of soil categories on a scale of 1:25,000 [only covers part of Navarra], or a scaled of 1:100,000 [for the whole of the Navarra territory]. The agrological capacity of Navarra's soil on a scale of 1:25,000 has been evaluated using the classification system designed by USDA and has been adapted for the conditions found in Navarra. In this study, the physical conditions of the environment have been taken into account: climate, relief, soil and uses of soil.

In addition, vulnerability shall be determined using crop indicators [Low = Crops resistant to water stress, Medium - Crops with a medium level of resistance, and High = Sensitive crops]. This requires each crop to be identified and assigned a value on a qualitative scale of vulnerability. Based on this scale, the annual SIGPAC map can be reclassified, assigning a degree of vulnerability to each area based on the type of crop.

Monitoring: In principle, this will not be calculated. This would be a one-off calculation of the initial situation.

INDICATOR 67. Level of defoliation [%] per species [REFINA]

Impact indicator. The source of data for this indicator is the REFINA network. Data is available from 2018 onwards. It shows the level of defoliation per species and the number of trunks or stalks for each species.

Monitoring: Annual

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INDICATOR 68. Daily thermal oscillation

Climate variable. The average daily thermal oscillation over an annual and monthly basis, i.e. the maximum temperature minus the minimum temperature. For observed data, the oscillation shall be monitored for a selection of weather stations and their entire historical data series, in order for them to match up with those used for AdapteCCa. For estimated data for models and emissions scenarios, the same analysis can be carried out using the daily estimated maximum and minimum temperature indices.

In addition, it would be interesting to analyse thermal comfort in the built environment based on data collected at ten-minute intervals at automatic weather stations, to discover the time at which the minimum and maximum temperatures occur.

Monitoring: Annual and monthly. Retrospective and future prediction based on climate scenarios.

INDICATOR 69. Non-native invasive species

Impact indicator. An indicator included in the list of "Overall indicator of adaptation to the main impacts of climate change in Catalonia" [36]. From the Spanish Catalogue of invasive exotic species [37] we can determine the species detected in Navarra. Additional information can be found in the Environment status report by the Government of Navarra [53].

Monitoring: Annual

INDICATOR 70. % Mediterranean pine trees infested with pine processionary moths (infestation levels 3, 4 or 5)

Impact indicator. First of all, we need to determine the biotic pathogenic agents which affect our forests, the distribution of which could be affected by climate change. This particularly includes the pine processionary moth, the prevalence of which is a result of climate change, and the previsions and possible solutions to this issue are described in [38].

[103] cites defoliation and reduced growth in southern Scotch pine forests (*Pinus sylvestris*) caused by the pine processionary moth (*Thaumetopoea pityocampa*). The increase in winter temperatures facilitates the survival of larvae for the pine processionary moth.

The data source can be found in the annual monitoring report [58].

Monitoring: Annual

INDICATOR 71. No. of incidents reported due to pest infestations and diseases in forests

Adaptation indicator. The data source shall be examined and monitored annually by the Office for Planning and Programming in the Natural Environment within the Department for the Natural Environment. The total number of incidents shall be monitored and split into the following categories: T1: Animals or grazing, T2: Insects, T3: Fungi, T4: Abiotic damage, T5: Direct human activity, T6: Fires, T7: Known local or regional contamination, T8: Other damage (mites, bacteria, nematodes, viruses,

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phanerogamic parasites and others). In addition, and depending on the availability of data, the total forest area in which pest infestation control initiatives are being carried out could be monitored.

Monitoring: Annual

INDICATOR 72. Thermal amplitude

Climate variable. Annual difference between the average temperature of the coldest month and the hottest month, calculated for each weather station. This allows a distinction to be made between a coastal climate (no more than 15-16°C) or an inland or continental climate (more than 16°C). The historical data series relating to the daily minimum and maximum temperature at each station has been homogenised using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)
- Insignificant or stationary trend
- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

Monitoring: Annual

INDICATOR 73. No. of people over the age of 80 who live alone

Vulnerability indicator. Elderly people who live alone are especially vulnerable to the progressive increase in temperatures and the effects of heat waves. The Institute for Public and Occupational Health in Navarra is already monitoring this indicator. Data for each basic health care zone is provided annually, broken down by gender, and monitored annually.

Monitoring: Annual

INDICATOR 74. Percentage of forest affected by defoliation (tier I network)

Impact indicator. The data source for this indicator is the European Network of Damage to Forests, Level I [104]. This is a large-scale, state-run network monitoring the health and vitality of forests, covering all of Europe with 7,500 control points arranged in a grid with sections of 16 x 16 km. These carry out an annual analysis of the health condition of trees and the main factors which have a negative impact on them, by evaluating routine parameters such as a loss of tree foliage (defoliation), determining the agents causing damage to trees, their fruiting levels etc. The number of control points in Navarra is currently 18 (Goizueta, Bértiz-Arana, Basaburúa Mayor, Lanz, Sierra de Urbasa, Esteribar, Lower Abaurrea, Ochagavía, Metauten, Guesálaz, Uterga, Aranguren, Upper Urraul, Leoz, Lumbier, Javier, Baztan and Isaba) which include Quercus robur and/or Quercus petraea oaks, beech trees (Fagus sylvatica), mixed leafy trees in the Atlantic biogeographic region, Scotch pines (Pinus

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sylvestris), mixed leafy trees native to the Mediterranean biogeographic region, black pines (Pinus nigra), holm oaks (Quercus ilex), mixtures of coniferous and leafy trees native to the Mediterranean biogeographic region.

Based on this source, and specifically the data from the 18 plots of land in Navarra (comprising 24 trees in each one), the average annual defoliation is monitored in each plot, and in total.

Monitoring: Annually, from 2019 onwards

INDICATOR 75. Changes in the distribution of species sensitive to climate change

Impact indicator. Using the species identified under indicator 59, and depending on the availability of map data, we can monitor not only their surface area, but also their distribution, and measure the average altitude and latitude of each species, thus enabling us to monitor the impact of climate change on the altitudinal and latitudinal distribution of the most vulnerable species. In principle, this would be difficult to monitor annually.

Monitoring: In principle, this will not be calculated.

INDICATOR 76. Number of drinking water treatment plants in flood plains

Exposure indicator. Based on this IDENA data from drinking water treatment stations (ETAP), we can filter the data down to those in flood plains. Partially static indicator as it practically ended with the construction of new treatment plants. This could be reviewed and updated every four years.

Monitoring: Initial situation. To be updated if there are any changes.

INDICATOR 77. Vulnerability of transport networks

Vulnerability indicator. This involves identifying all of the impacts of climate change that affect transport networks, particularly railways and roads. Based on each of these dangers (floods, landslides, fires, expansion etc.), it will be necessary to detect "hotspots" of high vulnerability in order to prioritise the adaptation measures applied in these areas.

Monitoring: In principle, this will not be calculated. This would be a one-off calculation of the initial situation.

INDICATOR 78. Variations in the growing period of forest species

Impact indicator. Changes in phenology are one of the most visible impacts of climate change, and there has been a recorded trend of early foliation, flowering and ripening of fruit in some species such as oak, holm oak and olive trees, as well as herbaceous plants [39].

This indicator is monitored based on two different sources:

78-A. European Network for Monitoring Forests in Navarra. Level II (RESINA) [75]. A plot of land containing beech trees (*Fagus Sylvatica*) is monitored in Burguete. A phenological assessment is carried out on 20 trees in the plot, selecting those which are classed as dominant or co-dominant. A phase is considered to have started when 50% of the population is showing signs of doing so. The

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historical data obtained at plot 115Fs is presented, indicating the start and end of the phase, its duration or amplitude, the number of days elapsed between the 1st of January and the phase start date, and (as a rough indication of the influence that temperature has on the phenomenon) the degree days elapsed since the 1st of January (dormant vegetation period) and the beginning of the phase, determined by data collected from the weather station installed at the plot. More information under [112].

78-B. CANOPEE project [57]. This shows the data of the 12 plots located in Navarra under the CANOPEE project, in Aralar, Lizoain, Burgui and Garaioa, and monitors a series of trees of the species *Fagus sylvatica, Abies alba, Quercus petraea and Pinus sylvestris* respectively. In each plot of land, 36 trees are monitored, and since 2017 their phenological condition has been monitored, as well as the percentage of buds from week to week during the period where leaves appear.

Monitoring: Annual

INDICATOR 79. Increase in surface area with trees resistant to climate change

Adaptation indicator. This involves identifying the forest species most resilient to future climates and monitoring the surface area occupied by these species. In the same way as in previous indicators, this requires updated mapping.

Monitoring: In principle, this will not be calculated.

INDICATOR 80. Surface area of dry land agriculture (not returning crop residue to the ground)

Vulnerability indicator. The vulnerability of dry land crops is related to the maintenance of soil quality, meaning that the impact is smaller on systems where there is a greater level of crop residue returned to the ground [43]. The annually updated surface area of dry land agriculture can be obtained from SIGPAC, or the vector layer of PAC statements filtered by type of irrigation = dry land. From the areas that correspond to dry land agriculture, it would then be necessary to determine, as an additional attribute, whether the crop residue is returned to the ground or not. However, it is not possible to quantify crop residue return unless it is within a conservation system.

Monitoring: In principle, this will not be calculated.

INDICATOR 81. Surface area of irrigated agriculture vulnerable to high salinity

Vulnerability indicator. The high level of salinity in plots of land within irrigation systems is increasing in areas with a deficit in water resources due to climate change. However, very long-term observations are required and their relation to climate change adaptation is not necessarily direct.

[45] summaries the study of problems relating to salinity in Navarra from different perspectives (Lines of work SERA-Salinity):

- Soil mapping which specifically takes into account areas affected by salinity (saline mapping E 1:25.000) (since 1981)
- Very detailed saline mapping for each plot of land studied (since 2003)

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- Development and application of new methodologies / technologies for diagnosing and mapping soil salinity (since 2003)
- Establishing integrated management systems for sustainable development in agricultural areas under irrigation, affected by salt levels (pilot area: Hondo de Espartosa) (since 2006).
- Setting up an experimental basin with irrigated agriculture (Landazuria) to study the contamination caused by irrigation (salt, N etc.) (since 2006).
- In future, salinity is to be monitored by INTIA in some plots of land, but outside the NAdapta scope of activity.

based on this data and the surface area of irrigated agriculture, obtained from SIGPAC or the vector layer of PAC statements filtered by type of irrigation = irrigated, we can mark out the surface area of irrigated zones that are vulnerable to high salinity, on a regional level or just for plots in the study or experimental basins.

Monitoring: In principle, only once. Initial situation.

INDICATOR 82. Agricultural surface area per municipality (ha)

Exposure indicator. Agricultural surface area is exposed to various threats caused by climate change. The agricultural surface area is monitored using SIGPAC from each year as a summation of the agricultural uses defined in [120].

Monitoring: Annual

INDICATOR 83. Adaptation of potential new areas

Adaptation indicator. Under [59], another proposed adaptation measure is to mark out "areas which although not currently suitable (but not incompatible either) with the current woodland, models predict that they may become more suitable in future. These areas should be prepared to facilitate not just natural colonisation where possible, but also the transfer of individuals, ensuring that their future management would be compatible with any predicted changes in use. Planning pilot studies relating to potential new areas could be an interesting starting point and should be the subject of further research" [59]. An interesting methodology to follow could be [29].

Monitoring: In principle, this will not be calculated.

INDICATOR 84. Surface area (m²) with sustainable drainage systems

Adaptation indicator. One of the adaptation measures included in the project is the implementation of sustainable drainage systems (SUD) in urban areas of Navarra (action C2.3). The aim of SUD is to reduce the inflow circulating over the surface of the system and to significantly reduce the amount of contaminants found in run-off water. These types of systems cover a large number of elements (infiltration systems or source control, permeable transportation systems, passive treatment systems, as well as resources for management, legislation, awareness etc.).

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Firstly, there are plans to introduce SUD systems in Tudela to demonstrate their advantages and the possibilities it has as a tool for managing run-off water and diffuse pollution generated in urban areas. If the results are good, this innovative water management system could be extrapolated and applied to other areas as a form of best practice for adapting to climate change.

In order to quantify this indicator, one option would be to record the cubic metres treated by each of these systems per year and to monitor this information annually. It appears to be difficult to obtain this data, so a more viable alternative could be to monitor the total surface area in metres squared.

Monitoring: In principle, this will not be calculated.

INDICATOR 85. Variation in water consumption specifically for irrigation (m³/ha.)

Adaptation indicator. The most significant adaptation measure for combating drought and water deficits is to reduce water consumption, which can be done in various ways.

INDICATOR 85a. Crop irrigation requirements (l/m²)

Irrigation requirements for crops are calculated based on ETo values, crop coefficients and useful precipitation. The efficiency of the irrigation is not taken into account when calculating this indicator, meaning that net requirements are used. The crop coefficients have been obtained from the Review of the FAO publication "Water requirements in crops". Sowing dates and the duration of phases for different crops have been determined based on surveys with farmers and engineers. The calculation formula is:

Net requirements: Kc*ETo-P

We use the data on irrigation requirements per surface area calculated by the irrigation advisory services at INTIA. These requirements are per crop and irrigable area. The most significant crops have been taken into consideration.

INDICATOR 85b. Reference evapotranspiration ETo (l/m²)

This is the evapotranspiration rate of a reference surface area, which occurs with no water restrictions. It does not take into account the type and development of the crop or management practices. This indicator is only affected by climatic parameters. It is calculated using the Penman-Monteith method. We use the ETo data calculated by the irrigation advisory service at INTIA in different irrigable areas.

INDICATOR 85c. Specific irrigation requirements (m³/t)

1. To calculate the specific water consumption of crops, we need to know the irrigation requirements of each crop per unit of surface area (indicator 85a) and also the production yields for the same unit of surface area. This information is required for each of the most significant crops.

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2. The Navarra Agricultural Bulletin [*Coyuntura Agraria*] is used to access the data on surface areas and production rates for irrigation crops in the study.

3. We use the data on irrigation requirements per surface area calculated by the irrigation advisory services at INTIA. These requirements are per crop and irrigable area. The most significant crops have been taken into consideration.

4. Specific consumption is calculated by dividing the irrigation requirements by unit of surface area by the production or yield expressed in tonnes for the same unit of surface area, ha. This calculation is carried out for the most significant crops in Navarra.

5. Finally, a weighted average is calculated for the specific consumption of all crops involved in the study.

Monitoring: Annual

INDICATOR 86. Bioclimatic belts

Climate variable. The bioclimatic zones give us large areas with common climatic features, which will be more or less suitable for different plant communities; therefore, the analysis has been focused on climate aspects, although obviously there are other factors upon which the development of different formations depends, such as soil characteristics (base content, depth etc.) or topography (slope gradient, exposure), the influence of which has a local influence on climate parameters and ultimately predetermines the conditions for the presence of one species or another.

The data for said parameters at each of the sampling points for each species have been extracted from the climate data observed in the period 1991-2019 and the climate projections associated with an emissions scenario of RCP8.5. The results obtained from the application of projected climate data for the periods 2021-2050 and 2051-2080 using the methodology applied to determine the bioclimatic zones reveal a worrying change in Navarra's bioclimatic characteristics.

The mapping of the bioclimatic zones for the aforementioned three periods has been obtained as a result of actions C6.1 and C6.2 of the LIFE-IP-NAdapta-CC project.

INDICATOR 87. No. of varieties and species introduced which are resistant to drought and tolerant of high temperatures

Adaptation indicator. The methodology would be based on providing a qualitative value of the level of resistance / tolerance that each variety has, and based on this value, setting a threshold at the beginning of the project. Over time, values will be assigned to new varieties that come onto the market. These values will be assigned in accordance with the behaviour they show in the GENVCE tests. Varieties that exceed the threshold will be added together. Finally, the total number of species grown will be listed qualitatively and categorised as resistant to drought or tolerant of high temperatures. This index can only be calculated retrospectively. A 3-year testing period is required (GENVCE) to determine resistance to drought and tolerance to high temperatures.

Monitoring: Annually, retrospective evaluation

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INDICATOR 88. No. of fires per municipality

Impact indicator. The data source for this indicator is the same as for 54: the National Forest Fires Database (EGIF), with data from 1985 to 2019. Data is added regarding the fires and includes the surface area burned (wooded forest area, non-wooded and non-forest), cause of fire (if it has been possible to determine this) and municipality. In recent years, the municipal council has also been included in many cases, and in some cases even specific coordinates. The web map shows the total number of fires in the period 2002-2019 and the annual changes in Navarra and each municipality.

- *Data from 2019 is awaiting validation*

Monitoring: Annual

INDICATOR 89. Percentage of area under cultivation with varieties resistant to drought

Adaptation indicator. An indicator to complement 87, but instead of monitoring the number of species, this indicator adds up the total surface area occupied by the previously identified species. The calculation is a straightforward sum of the area of all places in which the specified varieties grow above the threshold, divided by the total surface area. We would need to cross-reference the list of qualitative values with the data from the balance surveys for the season. The data sources are the grain surveys and network of GENVCE experiments, and the data can be monitored at a municipal level.

Monitoring: Annually, retrospective evaluation

INDICATOR 90. Risk index for landscape mediterraneisation

Risk indicator. Municipal risk index categorised from 1 (low risk) to 5 (high risk). This evaluates the percentage of change in the region, from Eurosiberian to Mediterranean, between the periods in question, for each administrative body. In the case of there being no change in the region and it staying as Eurosiberian, a calculation is made to see whether there has been a change to the Submediterranean version.

Monitoring: Not applicable

INDICATOR 91. Urban heat island

Impact indicator. The urban heat island effect refers to an urban area that is significantly warmer than its surrounding rural areas, as a result of buildings and human activity. This effect is calculated based on a combination of the surface temperature (LST) measured by the MODIS TERRA and AQUA satellites using the SUE algorithm (simplified urban-extent). Data is shown for each city, divided into day time and night time data, per year and per month.

Data source: Global Surface UHI Explorer (Yale University) [133]

Monitoring: Annual

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INDICATOR 92. Crop abandonment planning

Adaptation indicator. The adaptation measures recommended in the Roadmap for Climate Change in Navarra (KLINa) in relation to soil resources include crop abandonment planning in areas of marginal productivity and at risk of aridity. This indicator would be linked to more than one impact chain. The calculation method for this is still to be defined.

Monitoring: In principle, this will not be calculated.

INDICATOR 93. Livestock density (UGM/ha) per municipality

Vulnerability indicator. Exposure to animal diseases is determined by the number of livestock units (UGM). The number of animals per type and per REGA usage is defined by the livestock census. The number of animals is converted to UGM based on the equivalences listed in Appendix 1 of Autonomous Decree 31/2019. Total data for Navarra is shown, as well as data per municipality. Based on the livestock units and the agricultural surface area (indicator 82), we can obtain the livestock density in UGM per hectare, which measures the density of livestock and therefore how vulnerable a municipality is to animal diseases.

Source: Office for Agricultural Statistics. Department for Rural Development, Environment and Local Administration (UGM) and SIGPAC (agricultural surface area)

Monitoring: Annual

INDICATOR 94. Number of livestock units per municipality

Exposure indicator. Exposure to animal diseases is determined by the number of livestock units (UGM). The number of animals per type and per REGA usage is defined by the livestock census. The number of animals is converted to UGM based on the equivalences listed in Appendix 1 of Autonomous Decree 31/2019. Total data for Navarra is shown, as well as data per municipality.

Source: Office for Agricultural Statistics. Department for Rural Development, Environment and Local Administration (UGM)

Monitoring: Annual

INDICATOR 95. Risk index for impact on spaces of ecological and scenic interest

Risk indicator. Municipal risk index categorised from 1 (low risk) to 5 (high risk). Calculated for spaces of ecological and scenic interest with a sufficient surface area, spaces in the Network of Protected Natural Spaces in Navarra (RENA), Unique Landscapes and the Natura 2000 Network.

In order to take into account the most exposed areas of landscape, at least in the time scale of the project, these spaces are cross-referenced with the results of the risk analysis for impact on main elements of the forest landscape in Navarra, specifically selecting those which come out as being high risk in the period in question, 2051-2080, and we then calculate the hectares of each of these spaces of interest with high risk forest species. To complete the evaluation, for the areas considered to be at risk, we can calculate the hectares of the areas analysed within each administrative unit,

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which according to the data from the projections for the period 2051-2080, will change bioclimatic zones.

Monitoring: Not applicable

INDICATOR 96. Reduction in forest fragmentation

Adaptation indicator. [59] proposes a "reduction in forest fragmentation in areas where the trends in soil usage, another overall factor, would favour it. This approach follows the reasonable assumption that large forest areas will be more resistant to changes in climate than small areas that are more or less isolated from each other, due to their ability to create a more stable microclimate and to instigate changes which protect them against evapotranspiration, dehydration and soil erosion" [59]. Calculation method to be defined.

Monitoring: In principle, this will not be calculated.

INDICATOR 97. Livestock units died due to disease

Impact indicator. Using the tool for monitoring animal health, an outcome of one of this project's actions, we can establish an animal health indicator. This indicator should only focus on diseases for which the distribution and/or intensity could be affected by climate change, and which can be disaggregated by species. One source of data is the Government of Navarra's department for Animal Health.

Currently, there are only statistics for officially recognised diseases such as Brucellosis and Tuberculosis. The database could be expanded speaking to Veterinary Clinics and Agricultural Insurance organisations. The scale on which the information would be provided depends on the availability of data.

Monitoring: In principle, this will not be calculated.

INDICATOR 98. Surface area occupied by forest species under a high level of surveillance

Vulnerability indicator. One data source of particular interest for this indicator is the POCTEFA CANOPEE project [57]. The information provided by the Geoportal for the Pyrenean Climate Change Observatory (OPCC) [93] includes the Current Climate Surveillance map (VCA) for a range of forest species (*Abies Alba, Fagus Sylvatica, Quercus Ilex, Quercus Robur, Quercus Pyrenaica, Quercus Suber, Pinus Silvestris, Pinus Radiata, Pinus Pinaster, Pinus Nigra, Pinus Halepensis, Pinus Uncinata and Castanea Sativa*).

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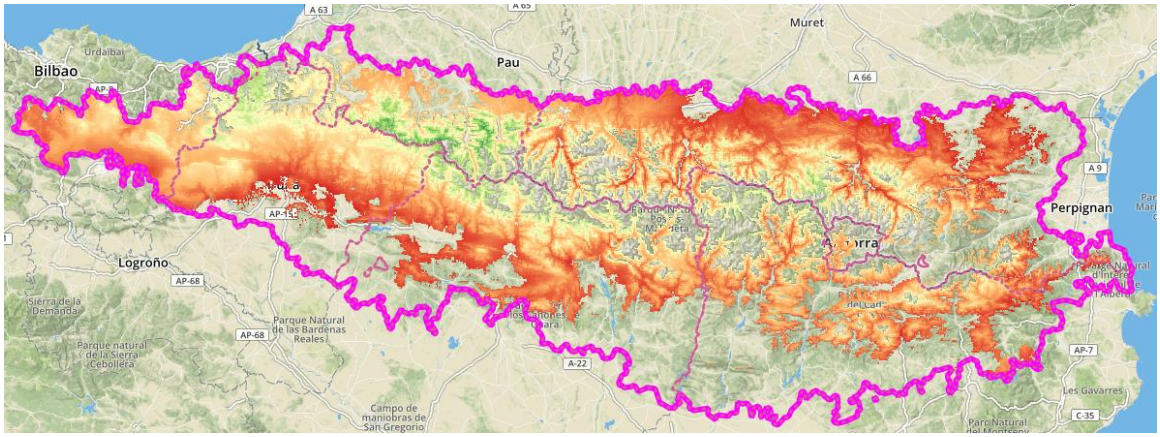


Figure 7. OPCC Geoportal. Vulnerability of Fagus Sylvatica

This data has been obtained through statistical modelling (relationship between the current distribution of forest areas where the species is in the majority, and the average values of various relevant climate indices for the period 1981-2010). This indicator recommends different levels of surveillance for the populations being studied, depending on whether they are located in an especially dry or warm place compared to their overall Pyrenean area of distribution. Taking into account the variability and uncertainty of the climate, low levels of surveillance will not guarantee the survival of the species, and high levels will also not clarify whether a decline is taking place.

The limitation of this indicator, on the one hand, is that the study conducted at CANOPEE does not cover the whole of Navarra, and on the other hand it provides very useful, albeit static information which can only be used to identify an initial phase.

Monitoring: In principle, this will not be calculated.

INDICATOR 99. Risk index for impact on main elements of the forest landscape

Risk indicator. Municipal risk index categorised from 1 (low risk) to 5 (high risk). This index aims to quantify the risk of a scenic change to an administrative entity due to large areas of its forest landscape being affected by climate change, regardless of whether they are in a unique space.

This calculation also takes into account the results obtained for the period 2051-2080 regarding forest areas where the main species, one of those now considered to be more important for the Navarran forest landscape, is at high risk due to the potential change in climate conditions compared to the conditions in which it currently survives.

Monitoring: Not applicable

INDICATOR 100. Expenditure on phytosanitary products applied to crops (€/ha)

Adaptation indicator. This indicator gives a representation of the amount spent on phytosanitary products in (euros/ha), but it is not a direct indication of the total amount of these products used, as this indicator will largely depend on the availability and price of products used in each season. The

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historical data covers all years from 2004 onwards and the only crops selected are those for which the sample is sufficiently representative (a minimum surface area and exploitation per region).

Source: Office for Agricultural Statistics and Agricultural Studies. Department for Rural Development and the Environment. Indicators. Magnitudes. Accounting network [121].

Monitoring: Annual

INDICATOR 101. Number of alerts sent due to animal disease vectors (no./year)

Impact indicator. The D2 project monitoring indicator *"Number of warnings sent about animal disease vectors (No./year)"*, the calculation method for which is the responsibility of INTIA. This is a department which must be created when carrying out the NAdapta project. The availability of data is subject to when the department is created.

Monitoring: In principle, this will not be calculated.

INDICATOR 102. Number of alerts sent regarding emerging infestations (no./year)

Impact indicator. The D2 project monitoring indicator *"Number of warnings sent about emerging pests (No./year)"*, the calculation method for which is the responsibility of INTIA.

This is monitored using the Navarra Warning Station (EANa) managed by INTIA and lists all of the information relating to pest infestations. Based on the total number of warnings published by the station each year, from 2016 onwards, we can see the following information:

- Total no. of alerts for emerging pests (this is an indicator in itself) per year, together with the total number of non-emerging pests

- No. of alerts per crop group each year

- Average week of the year in which warnings are received each year

And for each crop, which can be selected from the drop-down list in the top-right of the dashboard:

- No. of warnings for each pest in a pie chart

- Average warning week per year

Based on the alerts recorded, we can differentiate between pests which are considered to be 'emerging' (i.e. they are either "new" or they are already present but their behaviour is changing) and those that are considered to be present, but in which we are not seeing any changes.

Monitoring: Annual

INDICATOR 103. Damage to property caused by flooding

Impact indicator. Although the uncertainty is still significant, there are several studies which indicate notable changes in flooding as a result of the impact of climate change; in fact, these effects can already be seen in some regions. Specifically the Roadmap for Climate Change in Navarra (KLINa)

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highlights that one of the major effects of climate change in north-west Europe is the increasing risk of river flooding, as has been confirmed with frequent flooding in Navarra in recent years.

Economically speaking, the insurance sector could be the most rapidly and intensively affected by the effects of climate change, with storms and floods becoming more common and one of the highest payout costs for the sector [3]. This indicator is obtained based on the claims rate recorded by the national Insurance Compensation Consortium (CCS) when covering extraordinary risks, relating to:

- Claims for damage to property
- Date of occurrence: 1996-2019
- Causes: Flooding (not including impact from waves by the coast) and atypical cyclonic storms (according to the current definition at the time -Regulations for extraordinary risks).
- Geographical area: Navarra

The information provided is:

- Date of incident
- Cause
- Municipality
- Population
- Postcode
- Risk class
- Total cost: paid and provisioned but unpaid.

The results relay the information of the claims recorded (and not refused) as at 31/12/2019. The economic data has been deflated based on the annual IPC for Navarra.

The limitation of this indicator is that its development does not depend only on damages caused by flooding and cyclonic events, but also the evolution of the total amount of property insured each year.

INDICATOR 104. Number of people subscribed to alerts regarding emerging pest infestations (no./year)

Adaptation indicator. The D2 project monitoring indicator *"Number of recipients subscribed to emerging pests warnings (No./year)"* , the calculation method for which is the responsibility of INTIA. The data can be extracted directly from the warning station.

Monitoring: Annual

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INDICATOR 105. Agricultural surface area (ha) in areas at high risk of fire

Vulnerability indicator. Based on the mapping for risk of fires and cross-referencing this information with the agricultural parcels extracted from SIGPAC. If the mapping for risk of fires is available, then a risk threshold can be set and the agricultural areas with a risk above this threshold can be mapped, thus allowing us to calculate the figure for the surface area, broken down by local authority.

Monitoring: Annual

INDICATOR 106. Annual hectares of soil burned by fires (%)

Impact indicator. In order to calculate this indicator, it would be necessary to know the annual surface area burned (the EGIF database alone is not sufficient, as this only gives surface areas and at best the central coordinates in each case). This can be obtained by remote detection using the COPERNICUS Emergency Management Service [50] or another source of data.

Monitoring: Annual Retrospective, if data is available.

INDICATOR 107. Surface area with silvopasture, pasture and livestock management

Adaptation indicator. Silvopasture management is proposed as an essential mechanism for conserving the agricultural forest landscape, by preventing fires and preserving habitats and endangered species.

The best tool for measuring the development of pastures in recent years is SIGPAC. It specifically monitors the following uses:

- Pastures with woodland
- Pastures with shrubs
- Grasslands

The total surface area for each municipality corresponding to these categories has been calculated for the years 2005, 2013, 2018 and 2019, and based on this data, the percentage surface area.

The D2 project monitoring indicator *"Supported surface with silvopasture actions (ha)"*, the calculation method for which is the responsibility of INTIA.

Monitoring: Annually

INDICATOR 108. Agricultural soil exposure to erosion

Exposure indicator. Surface erosion of soil can be considered one of the main processes that contributes to the degradation of ecosystems (with environmental, social and economic implications), and it is one of the main causes of desertification on a regional and national level. At state level, there is a National Inventory of Soil Erosion (INES), which includes a map of laminar soil erosion, gully erosion, mass movements (typology and potentiality), channel erosion and wind erosion.

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This mapping can be cross-referenced with the agricultural areas extracted from SIGPAC, but monitoring is limited as this inventory is made once every 10 years and INES gives average figures. The only source of variation would be the agricultural surface area.

A more straightforward methodology would be to grade the exposure according to agricultural system (irrigation, herbaceous, woody irrigation, dry land) based on existing mapping (SIGPAC).

Monitoring: Initial situation. Annual monitoring could take place if source data is updated.

INDICATOR 109. Surface area at risk of desertification

Vulnerability indicator. MAPAMA, within the National Programme of Action against Desertification [51] has published a map of desertification risk from 2008 to a scale of 1/50000. This is a good starting point for determining the surface area of Navarra that is at risk of desertification, although it does not appear to be possible to monitor it annually due to a lack of availability of data regarding possible changes to zones and irrigation.

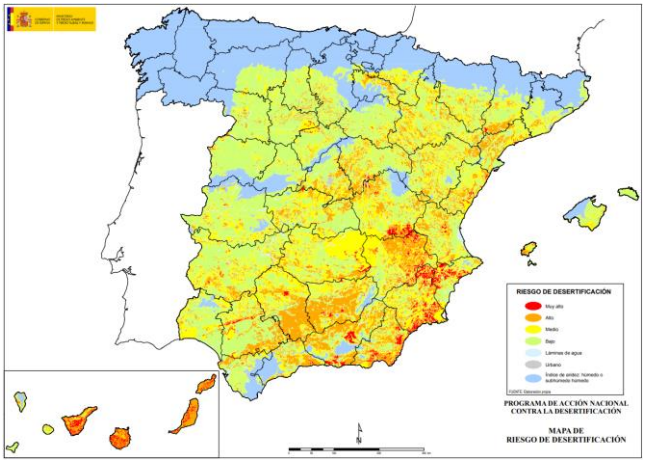


Figure 8. Mapping for risk of desertification Source: MAPAMA

Monitoring: In principle, this will not be calculated.

INDICATOR 110. Loss of soil due to water erosion

Impact indicator. This is not easy to monitor, but it can be based on data collected at the experimental basins (Latxaga, La Tejería, Landazuría and Oskotz), as was done in the Report on Indicators for the PDR Navarra Environmental Monitoring Plan 2014-2020 [47], monitoring the average values of water erosion (measures as a loss of soil in tonnes per hectare) in the experimental basins in Navarra.

In [19], the surface area of productive land lost through soil erosion is defined as an indicator. The Methodology has not been determined.

Monitoring: In principle, this will not be calculated.

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INDICATOR 111. Risk index for impact on main elements of the agricultural landscape

Risk indicator. Municipal risk index categorised from 1 (low risk) to 5 (high risk). This index aims to quantify the risk of a scenic change to an administrative entity due to large areas of its agricultural landscape being affected by climate change. This calculation also takes into account the results obtained for the period 2051-2080 regarding vineyards, which are representative of the Mediterranean agricultural landscape, and the Atlantic fields, representative of the Eurosiberian agricultural landscape. In the case of vineyards, this takes into account hectares within a municipality belonging to a D.O., with a high risk of no longer being classified in the period considered as having a low potential for producing good quality wines due to the climate. In the case of fields, it will quantify the number of hectares within each municipality with a high risk of being affected by changes in climate conditions which are currently characteristic.

Monitoring: Not applicable

INDICATOR 112. Surface area with fallow land and mulching for moisture retention and organic material

Adaptation indicator. The surface area with fallow land (traditional, environmental with or without coverage) can be obtained using the statements and inspections by PAC. One of the main threats of climate change is the increase in erosion, and in order to tackle this, [20] proposes an adaptation measure, which is to modify fallow land and mulching practices to retain moisture and maintain organic material, and the use of intercropping to optimise the use of moisture in the soil.

If the aforementioned practices are used and recorded (a common method is to allow grass to grow, cut it and then leave it on the land), then the surface area can be obtained and these areas can be mapped. This is not currently possible on a territorial level, but it is possible in control plots.

Monitoring: In principle, this will not be calculated.

INDICATOR 113. Storage of soil organic carbon

Adaptation indicator. Linked to the project monitoring indicator *"Soil organic C storage in implementation areas [Tons/ha 0-30 cm]"*, the responsibility for which is INTIA / UPNA. It will be measured in a network of control plots that are representative of the current variability in Navarra.

Monitoring: In principle, this will not be calculated.

INDICATOR 114. Reduction in erodability of soil

Adaptation indicator. The D2 project monitoring indicator *"Reduction of soil erodability [K and C factors of RUSEL equation, or potential tons/ha]"*, the calculation method for which is the responsibility of INTIA / UPNA. It will be measured in a network of control plots that are representative of the current variability in Navarra. Closely related to indicator 113.

Monitoring: In principle, this will not be calculated.

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INDICATOR 115. Index of change in common bird populations

Impact indicator. The report "Obtaining indicators for the status of biodiversity in the Autonomous Community of Navarra through the common breeding birds monitoring programme", set up by SEO/BirdLife for the Gorosti science society shows the results of long-term monitoring of common bird populations dispersed throughout Navarra between 1998 and 2018.

This is an additional indicator which incorporates the abundance and diversity of a selection of common bird species associated with different environments (urban, shrubland, agriculture, grain farming, tree farming, mosaic environment, field environment, forest, Eurosiberian forest, Mediterranean forest and aquatic environment). Rare species are not included in the index. This indicator is proposed by the European Environment Agency and added at SIOTN [49].

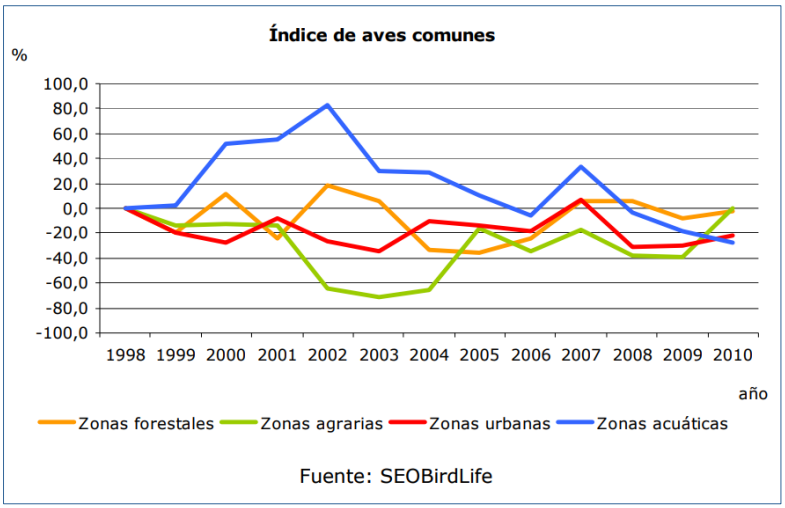


Figure 9. Source: Environment status report by the Government of Navarra [53]

This can simultaneously be an impact indicator relating to the loss of biodiversity caused by climate change, among many other factors, and an adaptation indicator which shows a positive trend resulting from the implementation of measures that encourage biodiversity in each environment.

Monitoring: Annual

INDICATOR 116. % surface area registered as ecological agriculture

Adaptation indicator.

116.1 Table

The data source is the Ecological Agriculture Register of Navarra (natural persons or legal entities which produce, convert, create, distribute or import to third party countries, any ecological products

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arising from ecological agriculture), any claims for which are approved by the Council for Ecological Agriculture Production in Navarra (CPAEN/NNPEK).

This shows the official statistics for ecological activity in Navarra in recent years (2013-2018). Specifically the surface area of crops in hectares:

- Qualified in the first year of practice (a)
- Qualified through conversion (b)
- Qualified through ecological agriculture (c)
- Total surface area (a+b+c)

The surface area is broken up into crops on arable farms, permanent pastures, permanent crops, cultivated mushrooms, fallow land and other surface areas (unspecified crops),

116.2. Map

The surface area of ecological agriculture per municipality is calculated based on the plots of land registered on 31/12/2021 (Source: Council for Ecological Agriculture Production in Navarra (CPAEN/NNPEK)), as certified, under conversion (CONV1 and CONV2), uncertified (first year) and not qualified, as the entire surface area is controlled and is managed in accordance with regulatory requirements.

The percentage of ecological agriculture is obtained based on the aforementioned sum of the surface area of ecological agriculture and the total agricultural and forest surface area in each municipality (Source: SIGPAC). The SIGPAC uses considered were IV, TA, TH, CF, CI, CS, CV, FF FL, FS, FV, FY, OC, OF, OV, VF, VI, VO, PA, PR, PS, ZC, ZV and FO. *

* All of these agricultural and forest uses have been taken into account, as there are plots certified as ecological agriculture such as pastures which are considered as being under PA, PS, FO or other uses in SIGPAC.

Source: Council for Ecological Agriculture Production in Navarra (CPAEN/NNPEK).

Monitoring: Annual

INDICATOR 117. Average minimum daily temperature (TNM)

Climate variable. Based on the homogenised series of historical data from each manual weather station in Navarra, the annual average of the daily minimum temperature is calculated, along with the trend line for the entire series of historical data. In addition, it should be possible to show the data on a monthly basis.

The homogenisation has been completed using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

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The annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)

- Insignificant or stationary trend

- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

Monitoring: Annual

INDICATOR 118. Climate change risk to forest landscape components

Risk indicator. The stands identifying each component (*Fagus sylvatica, Quercus robur, Abies alba, Pinus uncinata, Quercus humilis or Quercus pubescens, Quercus faginea, Pinus Sylvestris, Pinus halepensis and Quercus ilex*) are those whose species density is, at least 50 % of the forest, with the exception of black pine forests and fir forests, where, due to their uniqueness and low surface representation, all stands in which these species are present are included. The risk has been calculated for the following periods:

- Period 1991-2019
- Last half of the period 1991-2019, corresponding to 2006-2019
- Projected for the period 2021-2050 (RCP8.5)
- Projected for the period 2051-2080 (RCP8.5)

Monitoring: For 30-year periods

INDICATOR 119. No. of farmers subscribed to alerts service for self-protection against flooding

Adaptation indicator. Linked to the D2 project monitoring indicator *"No. of Alerts for Flood Self-Protection received by the Municipalities"*, the calculation method for which is the responsibility of Navarra Environmental Management (GAN-NIK). A decision should be made on whether this indicator is relevant or not, as it depends on the design of the alert system and its recipients.

Monitoring: In principle, this will not be calculated.

INDICATOR 120. % surface area occupied by species vulnerable to thermal stress and water deficit

Vulnerability indicator. The key aspect here is to identify these species. Based on a list, we can establish the initial surface area on the updated map (SIGPAC). An alternative would be to include a qualitative index of vulnerability based on an expert judgement and/or references and reclassify the SIGPAC areas, assigning them vulnerability index value based on the type of crop.

The data source would be the GENVCE experiments network, to assign the qualitative value and cross-reference this with data from the survey. The qualitative value can be assigned after 3 years of GENVCE experimentation, meaning that this index can only be calculated retrospectively. The index will only include cereals, particularly wheat and barley. The index only provides a comparative

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measurement between different varieties, but the "magnitude" of the difference will be difficult to calculate.

Monitoring: Annually and retrospectively, on a municipality level

INDICATOR 121. Progress in foliation, flowering and fruiting of plant species

Impact indicator. The monthly bulletin "Coyuntura Agraria" [27] has listed the phenological status of the main crops per agricultural region since 2010. The status, measured using the BBCH scale from 0 to 100 [134], depends on a range of factors, such as the sowing date, thermal integral, varietal type and selection of land plots for the sample. However, the development of the historical data series provides information of great interest regarding the phenological trends for the crops analysed.

Monitoring: Annual

INDICATOR 122. Overall index for risk to landscape

Risk indicator. This calculation also takes into account the 5 sub-indices that make it up (indicators 90, 95, 99, 111 y 132), assigning a value to the maximum risk class for that item. The objective is to warn municipalities of any existing risks, in any of the estimations that have been made.

Monitoring: Not applicable

INDICATOR 123. Average maximum daily temperature (TXM)

Climate variable. Based on the homogenised series of historical data from each manual weather station in Navarra, the annual average of the daily maximum temperature is calculated, along with the trend line for the entire series of historical data. In addition, it should be possible to show the data on a monthly basis.

The homogenisation has been completed using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The annual value is shown alongside its trend line. Additionally, and for each weather station analysed, this trend has been divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)

- Insignificant or stationary trend

- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

In the project "Impacts, vulnerability and adaptation to climate change of Spanish biodiversity" [59], there is an analysis of the potential distribution areas of different floral species based on the future climate, and to achieve this, three monthly climate indicators are taken into account: Average of the maximum temperatures, average of the minimum temperatures and total precipitation.

Monitoring: Annual

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INDICATOR 124. % of population aged > 65

Vulnerability indicator. When it comes to assessing the vulnerability of the population to the effects of climate change, in particular to heat waves, it is important to identify any groups that are especially vulnerable. Based on population data, disaggregated by age group for each municipality [11], we can find the total number of people over the age of 65 in absolute terms, and as a percentage in relation to the whole population. All of the statistical indicators which relate to people must be disaggregated by gender in order to identify and evaluate the potential impact on both men and women.

Monitoring: Annual

INDICATOR 125. Area cultivated with plant varieties that are tolerant to abiotic stress

Adaptation indicator. Linked to the D2 project monitoring indicator *"Cultivated area with plant varieties tolerant to abiotic stress [ha]"*. We need to determine new plant varieties, recommended for their environmental adaptation abilities and/or efficient use of water. Once this has been done, we can find the total cultivated area containing these varieties based on the annual PAC statements. The data sources are the grain surveys and network of GENVCE experiments.

Monitoring: Annually and broken down by municipality.

INDICATOR 126. No. of consecutive days where Tmax > threshold over a range of dates (dynamic, per crop)

Climate variable. A climate variable to be extracted from future data, estimated using regional models and associated climate scenarios. Based on data for the maximum daily temperature, we can determine the number of days which exceed a threshold value within the defined range of dates, and create a binary yes/no indicator based on whether there are 3 consecutive days which meet this condition or not. The indicator should be dynamic as both the threshold value and range of dates vary for each crop.

There is already a mechanism which works using a database of observed data to achieve this. A decision should be made as to whether the same can be done using estimated data from AdapteCCa.

Monitoring: In principle, this will not be calculated.

INDICATOR 127. Daily thermal integral calculated using temperatures recorded every half an hour (base 10°C and t < 30°C) over a range of dates

Climate variable. A climate variable to be extracted from the data observed at weather stations (in this case, it is difficult to make future estimates as there is no half-hourly data available for the climate scenarios).

Monitoring: In principle, this will not be calculated.

INDICATOR 128. % of population aged 15 or less

Vulnerability indicator. Same methodology as for indicator 124.

Monitoring: Annual

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INDICATOR 129. Percentage of homes over 40 years old

Vulnerability indicator. Created by Lursarea based on land registry data (land registry parcels and table of urban units). The sum of homes per municipality has been calculated, as well as the sum of homes over 40 years old (based on the year of construction listed in the land registry), and based on both of these totals we can work out the percentage. Homes are considered to be urban units with a purpose or destination code = 4 and a surface area of more than 35m².

Monitoring: Annual

INDICATOR 130. Level of crop exposure to increased water deficit

Exposure indicator. This involves identifying crops that are exposed to an increased water deficit (less rain and/or more ETP), and/or monitoring their surface area with a binary index (exposed / not exposed), or grading their exposure according to their agricultural system (low = herbaceous irrigation, medium = woody irrigation, high = dry land) based on existing mapping (SIGPAC). A problem arises when grading the exposure of each crop and/or agricultural system to the increasing water deficit based on an expert judgement.

INDICATOR 131. % surface area of green spaces (including forests)

Vulnerability indicator. Highly artificial areas are particularly vulnerable to heat waves. By contrast, a built environment with plant life or a nearby green space is less vulnerable. Vulnerability can be graded on a municipal level based on the percentage surface area of green spaces located within urban town or city centres. The map to be used here could be the updated Map of Crops and Utilisation in Navarra.

Monitoring: Annual, if data is available

INDICATOR 132. Index of risk caused by a change in bioclimatic zone affecting the landscape

Risk indicator. Municipal risk index categorised from 1 (low risk) to 5 (high risk). This consists of comparing the percentage change between the current period (1991-2019) and the future period (2051-2080) of the corresponding maps of bioclimatic sectors from a bioclimatic perspective (APB) and their respective bioclimatic zones.

Monitoring: Not applicable.

INDICATOR 133. Energy poverty per CP

Vulnerability indicator. It would be interesting to look at data relating to energy poverty to identify vulnerabilities linked to heat waves. This data would have to be disaggregated by gender, as women are more susceptible to energy poverty and are responsible for energy supply in many places around the world. In the event that this data is not available, it could be linked to the risk of poverty.

Monitoring: Annual

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INDICATOR 134. Variations in yield of main crops

Impact indicator. Within the scope of food production systems, specifically in relation to the main crops, forecasts indicate that climate change without any adaptation will have a negative impact on production, with a local temperature increase of 2°C or more above the levels seen at the end of the 20th century, although there may be regions which benefit from this increase. The projected impacts would vary for different crops and regions and different adaptation scenarios [105].

The ratio between production (tonnes) and productive surface area (ha.) of the main crops (the 10 most common crops in Navarra have been selected), by type of irrigation (dry land, irrigated and total), and per agricultural region. The production per region and crop, and the surface area of cultivation as the primary or main occupation, subsequent and associated occupations have all been obtained annually since 2000 from the following source:

Source: Office for Agricultural Statistics and Agricultural Studies. Department for Rural Development and the Environment [113].

Monitoring: Annual per agricultural region.

INDICATOR 135. CTE Climate zones

Climate variable. The Technical Building Code (CTE) is the standard framework which sets out the requirements which buildings must meet with regards to basic safety and habitability requirements set out in Law 38/1999 of 5 November, regarding Building Regulations (LOE).

The CTE divides up the territory of Spain into climate zones in order to determine the requirements for limiting the energy consumption of buildings, depending on the climate zone of the location and the planned usage. According to the CTE guidelines, once the building's climate zone has been established, the conditions for said zone must be met when calculating the building's characteristics, in order to comply with energy efficiency requirements (Appendix H of DB-HE).

Current climate zones and those corresponding to the periods 2021-2050 and 2051-2080 are calculated based on projections associated with an emissions scenario of RCP8.5.

INDICATOR 136. Linear kilometres of open spaces improved for forest surfaces

Adaptation indicator. Opening up and improving forest pathways benefits accessibility to fire extinguishing resources, making it an effective adaptation measure to tackle a possible increase in the frequency and intensity of forest fires caused by climate change.

The information source for these three indicators is the forest relief work managed by the Office for Strategic Planning in the Natural Environment.

Monitoring: Biennial.

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INDICATOR 137. Urban sky view factor

Exposure indicator. Various studies have analysed the differing behaviour of extreme temperatures between the city and rural areas, as a function of the sky view factor (SVF) [82, 83, 84]. This can be calculated easily [85] using a Digital Elevation Model (DEM).

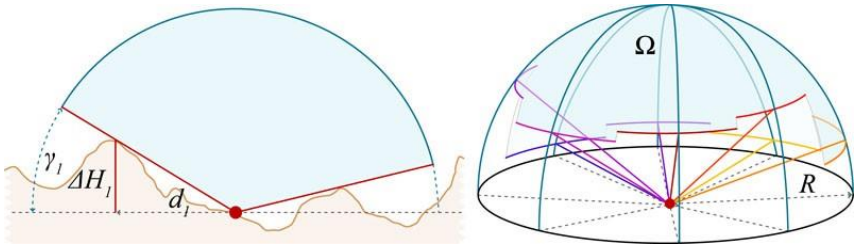


Figure 10. Sky view factor. Source: [85]

Using the SVF, we can work out the average values and determine the exposure, graded based on the percentage of sky hemisphere that is visible, which is measured by the SVF.

Monitoring: Initial situation. Fairly static indicator.

INDICATOR 138. Population density per municipality

Exposure indicator. Population density per municipality can be calculated easily based on the population and the area of each municipality. Using this, the exposure can then be graded in levels. Similarly, [86] uses home density in residential areas (Homes/ha.) (2008), categorising the exposure into four levels:

- Homes/ha. > 100 –> Very high exposure
- 65 < homes/ha. < 100 –> High exposure
- 50 < homes/ha. < 65 –> Average exposure
- Homes/ha. < 50 –> Low exposure

Data since 1998

Source: INE [122]

Monitoring: Annual

INDICATOR 139. Population per municipality

Exposure indicator. The population per municipality can be used to grade the exposure to the urban heat island effect. For example, in [87], exposure is graded in four levels based on set thresholds combining the total population, home density and air quality:

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	EFECTO ISLA DE CALOR			
	Alta	Media	Baja	Sin exposición
Tipologías	G	H	I	J
Criterios	pob_tot >80.000 o den_viv >100 o (pob_tot (30.000-80.000) y den_viv (65-100)	pob_tot (30.000-80.000) o (den_viv (65-100) y cal_air<93)	pob_tot (15.000-30.000) o (den_viv (50-65) y cal_air<93)	pob_tot <15.000

Figure 11. Exposure to urban heat island. Source: Udalsarea [87]

Data since 1998

Source: INE [122]

Monitoring: Annual

INDICATOR 140. Increase in productivity in irrigation farming

Adaptation indicator. The GIZ Repository of Adaptation Indicators includes this indicator, which "gives information on the potential increase in productivity arising from land with irrigated agriculture as an adaptation measure" [19]. The data generated allows us to make comparisons regarding production levels of over different time periods and territories. This indicator does not provide information on the specific causes or combination of causes that lead to greater productivity apart from irrigation, and both crop productivity and irrigation savings are taking into account in other indicators.

The data source is the GENVCE tests, comparing the irrigation system with dry land in arid and semi-arid zones, or using data from the balance surveys for the season. The evaluation shall be limited to the main cereal crops (winter) grown in both systems.

Monitoring: Annually for Navarra and per municipality

INDICATOR 141. Density of urban fabric

Vulnerability indicator. Population in the urban area of the municipality. The urban surface area is calculated as the sum of the areas with coverage comprising SIOSE 811, 812 and 813. This could be a better indicator for exposure to the heat island effect. Units: Inhabitants / hectare. Sources: NASTAT (population) and SIOSE (urban surface area). IDENA (municipalities).

Monitoring: Biennial. Fairly static indicator.

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INDICATOR 142. Map of vulnerability in the event of flooding caused by rain

Vulnerability indicator. Intensive rainfall can cause floods in urban areas. This type of flood can be more dangerous than those in situations where the city's drainage system is inefficient or an unsuitable size.

It would be interesting to carry out a study on the existing drainage network [64], both on the surface (geometry of streets, layout and type of grilles and gutters, longitudinal ans transverse slope gradients, water trajectories, crossroads, transverse sections etc.) and underground, including identifying conflicting points or potential flood zones (junctions, narrow sections, changes in slope gradient, areas located high up, below street level etc.).

Monitoring: In principle, this will not be calculated.

INDICATOR 143. No. of days with precipitation in the form of snow

Climate variable. It would be very useful to have observed and estimated data for precipitation in the form of snow. However, the weather stations do not differentiate between precipitation in the form of rain or snow, and the data is not very reliable. What can be recorded, though, is the number of days with snow recorded at the manual weather stations [123].

AdapteCCa does not list this variable, but it can be monitored monthly and annually for the entire historical data series of a select few stations, in principle those listed under indicator 1, which correspond to those listed by AdapteCCa under indices relating to precipitation.

Monitoring: Monthly and annually. Retrospective.

INDICATOR 144. NPK mineral fertilisers not used (Kg/ha) – Substituted with organic material

Adaptation indicator. Associated with the D2 project monitoring indicators *"Raw material - N mineral fertilizer not used (KgN/ha) - Substituted with organic material", "Raw material - P mineral fertilizer not used (KgP2O5/ha) - Substituted with organic material"* and *"Raw material - K mineral fertilizer not used (KgK/ha) - Substituted with organic material".* Data shall be extracted from the land parcels being monitored.

Monitoring: Annually throughout the network of land parcels.

INDICATOR 145. Surface area of "cold" roofs and floors

Adaptation indicator. An adaptation measure aimed at reducing the heat island effect in cities. It is difficult to monitor this beyond a local level.

Monitoring: In principle, this will not be monitored.

INDICATOR 146. =Number of water sources and/or lakes installed

Adaptation indicator. An adaptation measure aimed at reducing the heat island effect in cities. It is difficult to monitor this beyond a local level.

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Monitoring: In principle, this will not be monitored.

INDICATOR 147. Green façades and roofs

Adaptation indicator. An adaptation measure aimed at reducing the heat island effect in cities. It is difficult to monitor this beyond a local level.

Monitoring: In principle, this will not be monitored.

INDICATOR 148. Surface area of conservation agriculture

Adaptation indicator. Associated with the project monitoring indicator *"Surface practising conservative agriculture [ha]"* the responsibility for which belongs to INTIA. Depending on the availability of data, this can be monitored annually and disaggregated throughout the territory by agricultural region. Data shall be extracted from the land parcels being monitored.

Monitoring: Annual

INDICATOR 149. Surface area that uses organic fertilizer

Adaptation indicator. Associated with the project monitoring indicator *"Surface using organic fertilization [ha]"* the responsibility for which belongs to INTIA. Depending on the availability of data, this can be monitored annually and disaggregated throughout the territory by agricultural region. Data shall be extracted from the land parcels being monitored.

Monitoring: Annual

INDICADOR 151. % Variation in mortality rate due to respiratory causes

Impact indicator. Following the method used in [69], we would need to start with Codes J00-J99 of the International Classification of Diseases and calculate the variation in mortality rate in one year of reference. It would be interesting to link this indicator with exposure indicators for air quality and disaggregate it by territory where possible.

Monitoring: Annual

INDICADOR 152. % Variation in mortality rate due to cardiovascular causes

Impact indicator. Following the method used in [69], we would need to start with Codes J00-J99 of the International Classification of Diseases and calculate the variation in mortality rate in one year of reference. It would be interesting to link this indicator with exposure indicators for air quality and disaggregate it by territory where possible.

Monitoring: Annual

INDICATOR 153. Average monthly and annual temperature

Climate variable. Based on the homogenised series of historical data from each manual weather station in Navarra, the annual average of the daily average temperature (the arithmetic mean of the

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minimum and maximum temperatures) is calculated. Further down the line, it should be possible to show the data on a monthly basis.

The homogenisation has been completed using the ACMANT method, using the computer program of the same name. This homogenisation is preferably carried out in a relative manner, i.e. taking into account neighbouring weather stations, and any gaps in data are always filled using interpolation.

The annual value is shown alongside its trend line, and the development of this trend line is show in degrees per decade, and for each station analysed, the trend line is divided into 3 categories:

- Trend of significant statistical increase (p value < 0.05 and negative gradient)

- Insignificant or stationary trend

- Trend of significant statistical decrease (p value > 0.05 and negative gradient)

Monitoring: Annual

INDICATOR 154. Emergency hospital admissions due to COPD

Exposure indicator. Indicator defined under [69]. This quantifies the number of emergency hospital admissions in the Autonomous Community of Navarra, codified with one of the following codes depending on the classification used:

-CIE 9: COPD and associated illnesses (490, 491, 491.0, 491.1, 491.2, 491.20, 491.21, 491.22, 491.8, 491.9, 492, 492.0, 492.8, 493.2, 493.20, 493.21, 493.22, 494, 494.0, 494.1, 496)

Annual data is available from 2000 to 2015, disaggregated by Autonomous Community and gender.

Source: Basic Minimum Data Set for Hospitalisation (CMBD-H).

Monitoring: Annual

INDICATOR 158. Green/river/safe routes

Adaptation indicator. The construction of green routes improves microclimate conditions in the areas where they are designed, with an increase in plant life, which also acts as a means of dampening the impact caused by flooding.

Monitoring: Annual, if data is available.

INDICATOR 160. Number of homes with energy rating A/B/C/D

Adaptation indicator. Another common adaptation measure is to reduce pollutant emissions with more energy efficient buildings [40]. This measure can be considered a mitigation measure, as its aim is to reduce emissions, but it can also be considered an adaptation measure, specifically in the urban fabric.

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Monitoring: Annual

INDICATOR 161. Concentration of potentially allergenic pollen in the atmosphere

Exposure indicator. This indicator presents information about the concentration of pollen (pollen/m3 of air), measured since 2011 for different taxons (*Acer Ligustrum, Alnus Morus, Artemisia Olivo, Betula Pinus, Carex Plantago, Carope platanus, Castanea poa* – Gramíneas, *Chenopodium Populus, Chopo Quercus,* Compuestas (ambrosia), *Rumex, Corylus Salix, Cupressus Ulmus, Ericaceae Urtica, Eucaliptus Hongo Alternaria*, *Fraxinus*, etc.) [10] and the pollen forecast bulletin differentiates between 4 categories depending on the concentration of pollen:

- < 20 grains/m^3 → Low
- 20-50 grains/m^3 → Medium
- 50-70 grains/m^3 → High
- 70 grains/m^3 → Very high

An uneven distribution of pollen concentration is seen, depending on the type of pollen taken into account at the sampling station. The added value of this indicator, as suggested in [69], is that there is the possibility to monitor its evolution over time and to identify variations in time, as well as explore the occurrence of seasonal peaks and early flowering, plus their intensity, which are changes caused by the effects of climate change

The starting data includes daily and monthly pollen reports by the Government of Navarra, and the average annual concentration is monitored along with the number of days where a threshold is exceeded (high or very high figure > 50 grains/m^3). As well as the gauging station in Pamplona, there is now also the Tudela station (2019) and the San Sebastian station (2020).

Monitoring: Annual

INDICATOR 162. Emergency hospital admissions due to allergy-induced asthma. Extrinsic asthma

Impact indicator. This quantifies the number of emergency hospital admissions in the Autonomous Community of Navarra, codified with the code CIE-9-MC: 493 (CIE9:493.0, 493.00, 493.01, 493.02).

Depending on the availability of data, this could be disaggregated territorially by municipality or local authority. Indicator defined under [69]. Annual data is available from 2000 to 2015 regarding emergency hospital admissions due to asthma, by Autonomous Community and gender.

Source: Basic Minimum Data Set for Hospitalisation (CMBD-H).

Monitoring: Annually and retrospectively

INDICATOR 163. Number of people under new climate change monitoring systems (pollen)

Adaptation indicator. A D2 project monitoring indicator, the calculation method for which is the responsibility of the Spanish Institute for Public Health (ISP).

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Monitoring: Annual

INDICATOR 164. No. of workers who work outdoors

Vulnerability indicator. This counts the total number of workers (employed and self-employed) exposed to high temperatures who carry out their work outdoors.

Source: Institute for Public and Occupational Health in Navarra. Department for Occupational Health and Safety. Department for Monitoring Health in the Workplace.

Monitoring: Annual

INDICATOR 165. Slope protection (grey infrastructure)

Adaptation indicator. One adaptation measure used to reduce the vulnerability of infrastructure to land slippage and landslides on slopes is slope protection.

Monitoring: In principle, this will not be monitored.

INDICATOR 167. No. of days above the alert threshold for Tmax and Tmin

Climate variable. The National Plan for preventative action against the effects of excess temperatures for health [67] has established minimum and maximum temperature thresholds for province capitals based on a study of 'trigger' temperatures that lead to mortality. In Navarra, these are currently used:

- For the Ebro river basin in Navarra, the thresholds for Zaragoza: 36°C T_{max}, and 20°C T_{min}
- For the rest of Navarra, the thresholds set for Navarra based on the range of temperature in Pamplona: 36°C T_{max}, and 18°C T_{min}

The criteria for assigning risk levels to situations of excess temperature, as defined in [67], are based on the minimum and maximum temperature thresholds (actual temperatures, not predicted) being exceeded at the same time, and this situation persisting over time. Risk levels are assigned using the following criteria:

- If the number of days in which the predicted maximum and minimum temperatures simultaneously exceed the respective threshold values is 0, then the index is "0", and the assigned level is called "**LEVEL 0**" or no risk, and this is represented by the colour green.
- If the number of days is one or two, then the indices are "1" and "2" respectively and the assigned level is called "**LEVEL 1**" or low risk, and is represented by the colour yellow.
- If the number of days is three or four, then the indices are "3" and "4" respectively the assigned level is called "**LEVEL 2**" or medium risk, and is represented by the colour orange.
- If the number of days is five, then the index is "5" and the assigned level is called "**LEVEL 3**" or high risk, and is represented by the colour red.

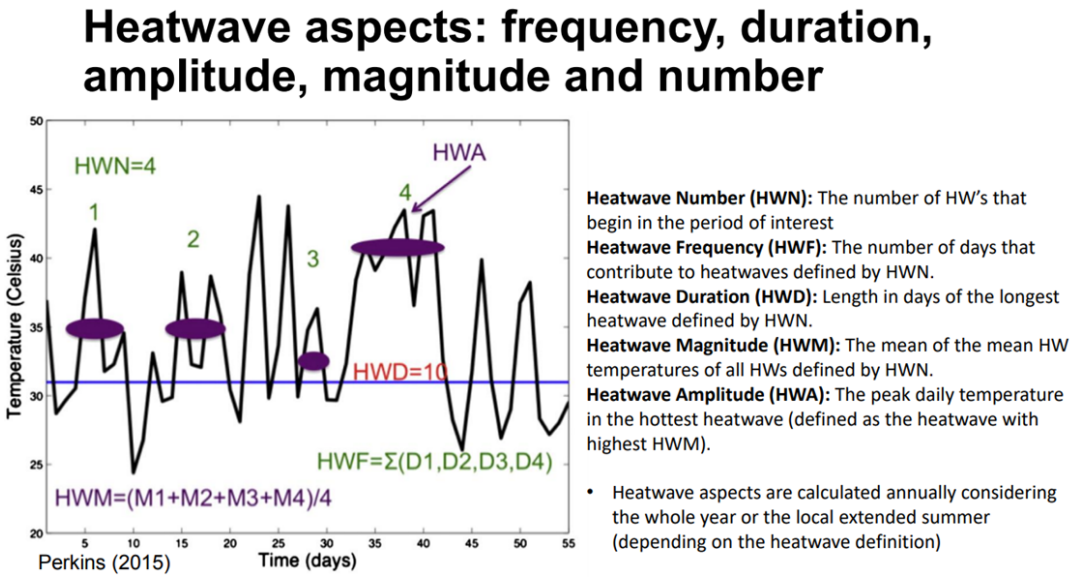
Monitoring: Annual

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INDICATOR 168. Magnitude, amplitude, number, duration and frequency of heat waves

Climate variable(s). 5 indicators have been calculated, defining the magnitude, amplitude, number, duration and frequency of heat waves for each period (1961-1990, 1991-2019, 2021-2050 y 2051-2080):

- **Magnitude of heat wave (HWM).** A heat wave is defined as 3 or more days in which the maximum temperature (TX) > the 90th percentile, where the percentiles are calculated based on the baseline period specified by the user. HWM is the average temperature of all heat waves identified by HWN.
- **Amplitude of heat wave (HWA)**, defined by the 90th percentile of TX. HWA is the maximum daily value in the hottest heat wave (defined as the heat wave with the highest HWM).
- **Number of heat waves (HWN)**, defined by the 90th percentile of TX. HWN is the number of individual heat waves that occur each summer (from May to September in the northern hemisphere).
- **Duration of heat wave (HWD)**, defined by the 90th percentile of TX. HWD is the length of the longest heat wave identified by HWN.
- **Frequency of heat waves (HWF)**, defined by the 90th percentile of TX. HWF is the number of days which contribute to heat waves based on those identified by HWN.



Source: [124]

Monitoring: Per climate period (1961-1990, 1991-2020 to be completed, 2021-2050 and 2051-2080)

INDICATOR 169. Poverty risk rate per Basic Health Zone

Vulnerability indicator. The population at risk of relative poverty (poverty risk rate) is the percentage of people who live in homes where the total equivalent annual income is lower than the poverty threshold. This can be disaggregated territorially into the 57 basic health zones in Navarra. This is

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related to energy poverty, which is difficult to monitor and could be a good indicator of vulnerability to the effects of heat waves.

In addition, the Navarra Statistics Institute (Nastat) [52] has data available on the risk of poverty, disaggregated by sub-area. Vulnerability can be graded based on a range of poverty risk levels. It would be interesting to look at the data on a municipal level.

Monitoring: Annual

INDICATOR 170. Hospital intake caused by effects of heat

Impact indicator. This quantifies the number of hospital admissions in Navarra's hospitals, codified with the code CIE-9-MC: 992 "Effects of heat and light", following the methodology used in the document "Indicators for Health and Climate change 2016", approved by the Commission for Public Health at the Inter-territorial Council for the National Health System [69]. This data can be monitored, disaggregated by age group and gender. It would be interesting to break down the data territorially for each municipality, or at least each climate zone in Navarra.

Source: Basic Minimum Data Set for Hospitalisation (CMBD-H).

Monitoring: Annual

INDICATOR 171. Number of deaths caused by exposure to excessive natural heat

Impact indicator. This quantifies the rate of mortality caused by exposure to natural excessive heat, codified as (CIE 10: X30). These indicators should act as a point of reflection for introducing adaptation measures such as those listed in the *National Plan for Preventative Action against the effects of excessive temperatures on health* [70].

Source: Institute for Public and Occupational Health in Navarra. Death Register

Monitoring: Annual

INDICATOR 172. Adaptation of evacuation systems in infrastructure (water volume)

Adaptation indicator. Both in the roads network and the railway network, there are sporadic problems with sanitation outflows, which could increase if heavy rain falls in a short space of time more often as a result of climate change [46]. For this reason, it is necessary to develop preventative measures such as the construction of new drains at critical points. The same happens with solid waste overflows in extreme precipitation events.

Monitoring: In principle, this will not be monitored.

INDICATOR 174. Materials in urban fabric (albedo)

Adaptation indicator. Artificial materials (especially asphalt and concrete), which are normally used in urban areas, are one of the main causes of the loss of thermal comfort in urban fabric. In order to tackle this danger, it is necessary to introduce measures into urban and land planning, such as modifying the albedo of materials used on the ground and in construction (increasing the level of

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incoming solar radiation being reflected), as well as expanding green spaces and creating biological corridors which allow for good ventilation in urban spaces.

Monitoring: In principle, this will not be monitored.

INDICATOR 175. Number of alerts caused by high temperatures

Climate variable. Three isoclimate zones have been identified in Navarra:

- The Cantabrian side of Navarra (743101)

- Central Navarra (743102) + Navarran Pyrenees (743103)

- Ebro river basin in Navarra (743104)

Although three isoclimate zones have been established, for practical purposes only two zones will be dealt with, as after the calculation of the threshold temperatures, the temperature in the Cantabrian side of Navarra (743101) and Central Navarra (743102) + Navarran Pyrenees (743103) came out very similar and the population of one of the zones is not enough to differentiate between the two zones. Alerts are based on 5-day temperature forecasts. The threshold temperatures are as follows:

Zone	T max (ºC)	T min (ºC)
Ebro river basin in Navarra	36	20
Rest of Navarra	36	18

Risk levels are assigned using the following criteria:

1. If the number of days in which the predicted maximum and minimum temperatures simultaneously exceed the respective threshold values is 0, then the index is "0", and the assigned level is called "LEVEL 0" or no risk, and this is represented by the colour green.

2. If the number of days is one or two, then the indices are "1" and "2" respectively and the assigned level is called "LEVEL 1" or low risk, and is represented by the colour yellow..

3. If the number of days is three or four, then the indices are "3" and "4" respectively the assigned level is called "LEVEL 2" or medium risk, and is represented by the colour orange.

4. If the number of days is five, then the index is "5" and the assigned level is called "LEVEL 3" or high risk, and is represented by the colour red.

Source: Institute for Public and Occupational Health in Navarra.

Monitoring: Annual

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INDICATOR 176. Native and imported cases of malaria, West Nile virus, Lyme disease, Mediterranean spotted fever, dengue fever, Chikungunya virus and Zika virus

Impact indicator. [69] includes additional indicators relating to vector-borne diseases, such as the number of detected cases of malaria, West Nile virus, Lyme disease, Mediterranean spotted fever, dengue fever and the Chikungunya virus. The data source for this is the National Network of Epidemiology Surveillance (RENAVE).

Monitoring: Annual

INDICATOR 177. Economic damage caused by expansion in roads

Impact indicator. The most significant direct impacts on linear transport infrastructure include the expansion of roads and railway lines. This translates to a shorter service life for infrastructure on the one hand, and on the other hand, an economic impact (potential blockages in the network) and social impact (expected increase in accidents due to environmental causes) [42]. A data source would need to be identified which allows the economic costs caused by these actions to be monitored.

Monitoring: In principle, this will not be monitored.

INDICATOR 178. Average annual concentration of particles (PM10)

Impact indicator. Climate change and poor air quality are two factors which act in synergy with each other. Fine particles, along with the tropospheric ozone, are the atmospheric pollutants which will be most influenced by climate change. The net global effect is unclear, but there will be significant variations at a local level. The Air Quality Control Network of the Government of Navarra consists of 9 stations distributed throughout the territory of the Autonomous Community. Based on these 9 air quality measurement and control stations, we can monitor the average annual concentration levels and how they develop.

Monitoring: Annual

INDICATOR 179. Area of land with invasive vector control (km²)

Adaptation indicator. A D2 project monitoring indicator, the calculation method for which is the responsibility of the Spanish Institute for Public Health (ISP).

Monitoring: Annual

INDICATOR 180. No. of surveillance points for invasive human disease vectors

Adaptation indicator. A D2 project monitoring indicator, the calculation method for which is the responsibility of the Spanish Institute for Public Health (ISP).

Monitoring: Annual

INDICATOR 181. Interior thermal comfort (home)

Impact indicator. Related to indicator 196. Thermal comfort in any interior setting is calculated based on four variables, which depend on the environment:

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- Average radiant temperature
- Air temperature
- Relative humidity
- Air velocity

And two variables which depend on the individual:

- Average metabolic activity in W/m^2, measuring the amount of heat that the human body needs to dissipate into the environment per square metre of skin in order to achieve a thermal balance, depending on the activity being carried out.
- Thermal insulation of clothing

Monitoring: To be determined.

INDICATOR 182. Kilometres of infrastructure in areas at high risk of land slippage

Exposure indicator. Based on the infrastructure (roads and railways, to be extracted from IDENA), we would need to define the vulnerable points, mainly linked to slope gradients in the land (based on a digital terrain model using LIDAR data) and soil characteristics (soil map of Navarra), but also estimated climate data. Methodology to be determined.

Monitoring: In principle, this will not be monitored.

INDICATOR 183. Economic damage caused by land displacement

Impact indicator. Methodology to be determined

Monitoring: To be determined

INDICATOR 184. Economic damage caused by landslides

Impact indicator. Depending on the availability of data, we would need to determine the total cost caused by landslides, affecting homes and infrastructure. In cases such as the flooding in February 2015, the damage caused to the Navarra Roads Network [77] has been divided up into landslides, subsidence, paved roads and land displacement.

Monitoring: To be determined

INDICATOR 185. Number and location of landslides

Impact indicator. A very useful indicator which should be based on an updated database with all of the landslides and land slippages on slopes recorded in Navarra, allowing black spots to be identified where action should be carried out as a priority. An interest data source on a state level is the "Tele-Ruta" service which records road damage or closures with a duration of more than 15' and records their cause. Causes that can be related to climate change include, in theory, snow, ice, landslides and floods. "Other causes" can also include other related incidents, for example wind. As indicated in [46], this database can be considered as representative of the incidents that occur over the whole state-

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owned road network. We would need to analyse whether this could also be translated exclusively to the area of Navarra.

Monitoring: To be determined

INDICATOR 186. Reducing the gradient of slopes

Adaptation indicator. One adaptation measure used to reduce the vulnerability of infrastructure to land slippage and landslides on slopes is reducing the gradient of slopes. However, this is a difficult measure to monitor. LIDAR values from different dates could be compared, but it would not be easy.

Monitoring: In principle, this will not be monitored.

INDICATOR 187. Reforesting slopes

Adaptation indicator. Another adaptation measure used to reduce the vulnerability of infrastructure to land slippage and landslides on slopes is reforesting slopes. Similarly to the previous case, this would be difficult to monitor.

Monitoring: In principle, this will not be monitored.

INDICATOR 188. Evacuation plans (people)

Adaptation indicator. The number of evacuation plans designed in infrastructure and homes which refer specifically to landslides.

Monitoring: In principle, this will not be monitored.

INDICATOR 189. Kilometres of infrastructure in flood plains

Exposure indicator. Kilometres of streets, roads and railway lines located in flood plains. The cross-references the layers of the central axes for streets, roads and railway lines with flood plains that have a return period of 500 years, and we then calculate the total sum of the length of these central axes that are located within a flood plain.

Sources: IDENA: Central axes of streets [125], roads [126] and railway lines [127]. Ministry for Ecological Transition: Flood plains [117]. IDENA (municipalities).

Date: 2018 (flood plains and municipalities), 2017 (streets), 2016 (roads) and 2014 (railway lines).

Monitoring: Initial situation. Fairly static

INDICATOR 191. Percentage of surface area that is impermeable

Exposure indicator. Greater permeability in the land within a municipality makes it more resilient against floods, as it filters more water. At the same time, an impermeable ground can indicate a greater presence of green spaces, which helps to reduce thermal sensation and acts as a sink for carbon dioxide. The data source that allows us to monitor the impermeability of the ground is some of the high resolution data from the Copernicus programme, called Imperviousness [78], which is currently available every three years (2006, 2009, 2012 and 2015).

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The products of impermeability capture the percentage and change in soil sealing. The areas constructed are characterised by the replacement of the original (semi-) natural soil coverage or water surface with an artificial covering, often impermeable. These artificial surfaces are usually maintained for long periods of time. The HRL impermeability captures the spatial distribution of artificially sealed areas, including the soil sealing level per unit of area. The level of soil sealing (degree of impermeability 1-100%) is found using a semi-automated classification model, based on calibrated NDVI. Based on this data, we can calculate the average degree of impermeability of the municipality for each date.

Monitoring: Every 3 years

INDICATOR 192. Km of infrastructure affected by floods each year

Impact indicator. Depending on the availability of data, we would need to determine the total number of kilometres of infrastructure affected by flooding. A data source for this is the demarcation of zones affected by flooding, available from IDENA in the case of floods from April 2018, which could be cross-referenced with the infrastructure data.

Monitoring: In principle, this will not be calculated.

INDICATOR 193. Fire brigade interventions required due to "water damage". Average annual interventions (Rate per 1000 inhabitants)

Impact indicator. Indicator listed under *"Analysis of vulnerability to climate change in the municipality of Madrid"* [72]. Depending on the availability of data, we would need to start with historical records of damage caused by flooding and interventions by emergency services caused by water damage, ideally disaggregated by territory. In order to work out the rate per 1000 inhabitants, we would also need to know the current population of each municipality.

Monitoring: In principle, this will not be calculated.

INDICATOR 195. Artificial green area and urban trees

Adaptation indicator. Adaptation measure aimed at reducing the heat island effect in cities. This measure is not only associated with the urban heat island, but also reduces municipal vulnerability to pluvial and fluvial flooding. First, all SIOSE (Spanish Land Use Information System) polygons containing the category ZAU (Artificial Green Area and Urban Woodland) and which are within urban areas are filtered (if they are partially within urban areas, they are clipped to the urban area boundary). Subsequently, the area of each of these polygons corresponding to ZAU is calculated from the total area and the percentage of ZAU. Finally, the sum of surface areas per municipality is calculated. The indicator is provided both in hectares and as a percentage of urban area (obtained from the urban centres layer of the cadastre).

Date: 2014

Monitoring: Depending on the SIOSE update.

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INDICATOR 196. Exterior thermal comfort (street)

Climate variable. This is established using tables. It establishes suitable areas of comfort for the "average" person with an average metabolism dressed in light clothing, sedentary and in environmental conditions without wind or solar radiation. When a group of individuals are exposed to a certain situation, it is called the "Average index value" (IMV), as the average of the respective values attributed to this situation, in accordance with the aforementioned scale.

In the work "Thermal Comfort" by P.O. Fanger [90], tables are provided which give different values for the average level of activity, such as total metabolic thermal load, dry temperature, relative velocity of air in relation to the body, and type of clothing, with all values corresponding to the IMV.

Monitoring: Annual

INDICATOR 197. No. of days where thermal sensation thresholds are exceeded

Climate variable. To be included in the future update for the AdapteCCa platform. AEMET takes into account a cold thermal sensation (wind chill) and hot thermal sensation (heat index). The latter takes into account the temperature and relative humidity, using the following formula [68]:

$$STC = -8.78469476 + 1.61139411 \cdot T + 2.338548839 \cdot HR - 0.14611605 \cdot T \cdot HR - 0.012308094 \cdot T^2 - 0.016424828 \cdot HR^2 + 0.002211732 \cdot T^2 \cdot R + 0.00072546 \cdot T \cdot HR^2 - 0.000003582 \cdot T^2 \cdot HR^2$$

Where STC is the Thermal Sensation Index for heat, T is the ambient air temperature in degrees Celsius, and HR is the relative humidity of the air in %. Based on these values of thermal sensation, AEMET has established the following four levels:

Caution: 27 to 32 → Possible fatigue with prolonged exposure or physical activity.

Extreme caution: 33 to 40 → Heat stroke, heat exhaustion, cramps possible with prolonged exposure or physical activity.

Danger: 41 to 53 → Heat stroke, heat exhaustion, cramps very possible with prolonged exposure or physical activity.

Extreme danger: 54 or more → Heat exhaustion, imminent heat stroke.

This variable is calculated based on data observed at automatic weather stations, as the manual stations do not measure relative humidity. Data should be obtained regarding the number of days in which the values 27 (caution), 33 (extreme caution), 41 (danger) y 54 (extreme danger) are exceeded.

Monitoring: Monthly and annually. Retrospective and future prediction based on climate scenarios.

INDICATOR 198. Atmospheric dispersal capacity

Climate variable. The factors which influence dispersion essentially fall under two types: climatic and topographic. The climatic factors determine the vertical and horizontal movement of air masses, while the topographic factors have a greater influence on the microclimate, where we can see

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changes in the behaviour of small parts of the atmosphere. In a neutral atmosphere, the atmospheric dispersal capacity is general proportional to the wind speed.

$$I = {}^{I_t I_v}/_{100}$$

Where *I* is the index for atmospheric dispersal capacity, I_t is the temperature and I_v is the dispersion of values for wind speed. The atmospheric dispersal capacity improves when I increases, and worsens when I reduces. Based on data from AdapteCCa, we can calculate this variable, both for observed data and for estimates based on climate scenarios.

Monitoring: In principle, this will not be monitored.

INDICATOR 199. Increase in shade

Adaptation indicator. One of the measures designed to reduce thermal stress for people is increasing shade by installing porches, awnings, shade covers on buildings etc. However, this is a difficult measure to monitor. Shade can be calculated for different solar geometries (HillShade geoprocessing) using a specific digital elevation model (DEM), based on LIDAR data, and the differences can be evaluated in the event of overhangs at a later date for comparison, although this analysis may make more sense on a local scale, to monitor a pilot study in a specific area to be examined.

Monitoring: In principle, this will not be monitored.

INDICATOR 201. Number of buildings less than 25 metres away from forest areas

Exposure indicator. Zones bordering forest areas or located inside them are at risk of forest fires. Any building or industrial establishment in this situation must implement the following safety measures, as stated in the Technical Buildings Code:

· [The building] must be separated from the forest area by a distance of 25 metres, which will be free from any shrubs or vegetation in order to prevent the forest fire from spreading.

As an approximation, based on the demarcations of buildings in the land registry, we can calculate the number of buildings less than 25 metres away from forest areas (source: SIGPAC, land parcels filtered by use = forest) per municipality. Building demarcations correspond to the borders of buildings in Navarra as registered with the land registry. It does not include all constructions. All of the industrial estates adjacent to one specific land registry parcel have been merged in order to achieve a more accurate representation of the number of buildings.

Monitoring: Every 4 years.

INDICATOR 202. Percentage of undeveloped land

Adaptive capacity indicator. (Surface area of ground that is NOT in the built environment / total surface area of the municipality) * 100. Undeveloped land (which is NOT in the built environment) is calculated as the difference between the total surface area of the municipality and the area occupied

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by urbanised developments as shown in the land registry. Sources: Land registry (urban centres) and IDENA (municipalities).

Monitoring: Relatively static. Data from 2019

INDICATOR 203. Surface area of empty space per inhabitant

Adaptive capacity indicator. Surface area of empty spaces / total population of the municipality (m^2/inhabitant). The surface area of empty spaces is obtained by subtracting the area corresponding to coverage consisting of 811, 812 and 813 (town centre, expansion and discontinuous) from the SIOSE simple coverage 101 (buildings). Divided by the total population of the municipality. Sources: System of Information on Ground Occupation in Spain (SIOSE) and NASTAT. IDENA (municipalities). Date: 2014 (SIOSE).

Monitoring: Fairly static. Requires updates from SIOSE to be monitored.

INDICATOR 204. Surface area of empty space in relation to urban areas

Adaptive capacity indicator. Surface area of empty space / surface area of developed land. The surface area of empty spaces is obtained by subtracting the area corresponding to coverage consisting of 811, 812 and 813 (town centre, expansion and discontinuous) from the SIOSE simple coverage 101 (buildings). Divided by the total sum of the urban area (811+812+813). Sources: System of Information on Ground Occupation in Spain (SIOSE). IDENA (municipalities).

Monitoring: Fairly static. Requires updates from SIOSE to be monitored.

INDICATOR 205. Accessibility to primary health care centres

Adaptive capacity indicator. Percentage of the population residing less than 5 minutes from a primary health care centre. Sources: Lursarea. OTN.

Monitoring: Annual.

INDICATOR 206. Municipality budget (€/inhabitant)

Adaptive capacity indicator. The initial revenue budget of Navarra per municipality, divided amongst the population of the municipality. Sources: NASTAT (municipal budget and population). IDENA (municipalities).

Monitoring: Initial situation (2016)

INDICATOR 207. Year of municipal planning approval

Adaptive capacity indicator. Current General Planning per municipality, including dates. As a mechanism gets older it becomes less effective, so it would be better to measure its potential or adaptive capacity. Sources: Urban Information System for Navarra. SIUN. [128] and IDENA (municipalities).

Monitoring: Initial situation (2019)

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INDICATOR 209. Artificial ground

Sensitivity indicator. [Surface area of artificial ground / total surface area of the municipality] * 100. Artificial ground is defined as the sum of areas corresponding to simple coverage of buildings [EDF], road, parking or pedestrian zone with no vegetation [VAP] and other constructions [OCT]. Sources: System of Information on Ground Occupation in Spain [SIOSE]. IDENA [municipalities]. Date: 2014.

Monitoring: Fairly static. Requires updates from SIOSE to be monitored.

INDICATOR 210. Number of homes per urban area

Sensitivity indicator. Total number of homes / Urban surface area of the municipality [ha]. The number of homes is obtained from the number of urban units corresponding to a home. The urban surface area is calculated as the sum of the areas with coverage comprising SIOSE 811, 812 and 813. Sources: Land registry. Table of urban units [homes] and SIOSE [urban developed land]. IDENA [municipalities]. Date: 2019 [urban units] and 2014 [SIOSE].

Monitoring: Annual

INDICATOR 211. Compactness of urban fabric

Sensitivity indicator. Volume constructed / urban surface area. The urban surface area is calculated as the sum of the areas with coverage comprising SIOSE 811, 812 and 813. The volume constructed is calculated as the product of the surface area with buildings within the urban surface area, multiplied by the average height of the buildings. **Sources:** Land registry. Buildings data and SIOSE [urban surface area]. IDENA [municipalities]. Methodology [130].

Date: 2019 [land registry] and 2014 [SIOSE].

Monitoring: The volume constructed can be monitored annually using land registry data, but the urban surface area [SIOSE] is not updated annually.

INDICATOR 212. No. of entities per municipality

Sensitivity indicator. No. of entities per municipality. Sources: IDENA. Population groups [129].

Monitoring: Initial situation [2018]

INDICATOR 214. Industrial plants in flood plains

Sensitivity indicator. Establishments with a CNAE linked to industry [CNAE codes 05.10, 05.20, 06.10, 06.20, 07.10, 07.21, 07.29, 08.11, 08.12, 08.91, 08.92, 08.93, 08.99, 09.10, 09.90, 10.11, 10.12, 10.13, 10.21, 10.22, 10.31, 10.32, 10.39, 10.42, 10.43, 10.44, 10.52, 10.53, 10.54, 10.61, 10.62, 10.71, 10.72, 10.73, 10.81, 10.82, 10.83, 10.84, 10.85, 10.86, 10.89, 10.91, 10.92, 11.01, 11.02, 11.03, 11.04, 11.05, 11.06, 11.07, 12.00, 13.10, 13.20, 13.30, 13.91, 13.92, 13.93, 13.94, 13.95, 13.96, 13.99, 14.11, 14.12, 14.13, 14.14, 14.19, 14.20, 14.31, 14.39, 15.11, 15.12, 15.20, 16.10, 16.21, 16.22, 16.23, 16.24, 16.29, 17.11, 17.12, 17.21, 17.22, 17.23, 17.24, 17.29, 18.11, 18.12, 18.13, 18.14, 18.20, 19.10, 19.20, 20.11, 20.12, 20.13, 20.14, 20.15, 20.16, 20.17, 20.20, 20.30, 20.41, 20.42, 20.51, 20.52, 20.53, 20.59, 20.60, 21.10, 21.20, 22.11, 22.19, 22.21, 22.22, 22.23, 22.29, 23.11, 23.12, 23.13, 23.14, 23.19, 23.20,

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23.31, 23.32, 23.41, 23.42, 23.43, 23.44, 23.49, 23.51, 23.52, 23.61, 23.62, 23.63, 23.64, 23.65, 23.69, 23.70, 23.91, 23.99, 24.10, 24.20, 24.31, 24.32, 24.33, 24.34, 24.41, 24.42, 24.43, 24.44, 24.45, 24.46, 24.51, 24.52, 24.53, 24.54, 25.11, 25.12, 25.21, 25.29, 25.30, 25.40, 25.50, 25.61, 25.62, 25.71, 25.72, 25.73, 25.91, 25.92, 25.93, 25.94, 25.99, 26.11, 26.12, 26.20, 26.30, 26.40, 26.51, 26.52, 26.60, 26.70, 26.80, 27.11, 27.12, 27.20, 27.31, 27.32, 27.33, 27.40, 27.51, 27.52, 27.90, 28.11, 28.12, 28.13, 28.14, 28.15, 28.21, 28.22, 28.23, 28.24, 28.25, 28.29, 28.30, 28.41, 28.49, 28.91, 28.92, 28.93, 28.94, 28.95, 28.96, 28.99, 29.10, 29.20, 29.31, 29.32, 30.11, 30.12, 30.20, 30.30, 30.40, 30.91, 30.92, 30.99, 31.01, 31.02, 31.03, 31.09, 32.11, 32.12, 32.13, 32.20, 32.30, 32.40, 32.50, 32.91, 32.99, 33.11, 33.12, 33.13, 33.14, 33.15, 33.16, 33.17, 33.19, 33.20, 35.15, 35.16, 35.17, 35.18, 35.19, 35.21, 36.00, 37.00, 38.11, 38.12, 38.21, 38.22, 49.20, 49.41, 50.20, 51.21, 51.22 and 52.10) and which were active in 2017 are considered to be industrial and their location is cross-referenced with the flood plains associated with a return period of 500 years to calculate the number of industries in flood plains per municipality. Sources: IndusLANd [131] (industrial establishments). Ministry for Ecological Transition (flood plains) [117]. IDENA (municipalities). Date: 2017.

Monitoring: Biennial

INDICATOR 215. Homes over 40 years old in flood plains

Sensitivity indicator. Homes over 40 years old exposed to floods with a return period of 500 years. Based on the table of urban units from the land registry, we can filter down to urban units where the destination/purpose code is a home, and the year of construction is prior to 1979 (40 years old). For each land registry parcel, the total number of homes over 40 years old is calculated and cross-referenced with the land parcels in flood plains with a return period of 500 years. The data does not tell us the exact location of the homes within the land registry parcel, meaning that this indicator takes into account all homes within a land registry parcel with a surface area that is completely or partially located within a flood plain. This approximation is considered to be tolerable. Data is provided in absolute terms (number of homes over 40 years old in flood plains) and as a percentage in relation to the total number of homes in the municipality. Sources: Ministry for Ecological Transition (flood plains) and land registry (demarcation of plots and table of urban units) IDENA (municipalities). Date: 2018.

Monitoring: Biennial

INDICATOR 216. Shannon Diversity Index for economic activity

Adaptive capacity indicator. Shannon index. This index is expressed as a positive number, which in most cases varies between 0.5 and 5, although the usual value is between 2 and 3; values lower than 2 are considered to be low in diversity, and values higher than 3 are high in diversity. Based on the register of workers in 2017 (per company address) per CNAE code (National Classification of Economic Activity) and per municipality, the index of economic diversity is calculated for each municipality using the following formula:

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$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

Where S = the number of CNAE codes and p_i = the proportion of workers with the CNAE code 'i' in relation to the total number of workers in the municipality (i.e. the relative abundance of activity 'i') Sources: NASTAT (workers). Date: 2017

Monitoring: Biennial

INDICATOR 217. Undeveloped land exposed to river flooding

Exposure indicator. (Surface area of undeveloped land exposed to river flooding / Surface area of undeveloped land) * 100. Undeveloped land (which is NOT in the built environment) is calculated as the difference between the total surface area of the municipality and the area occupied by urbanised developments as shown in the land registry. Sources: Ministry for Ecological Transition (flood plains) and land registry (town centres and municipalities). Date: 2018

Monitoring: Initial situation (2018)

INDICATOR 218. Artificial ground exposed to river flooding

Exposure indicator. Surface area of floodable artificial ground (return period of 500 years). Artificial ground is estimated as the sum of areas with simple coverage of buildings (EDF), road, parking or pedestrian zone with no vegetation (VAP) and other constructions (OCT). Sources: Ministry for Ecological Transition (flood plains) and SIOSE. Date: SIOSE (2014)

Monitoring: Requires updates from SIOSE to be monitored.

INDICATOR 219. Surface area of developed land in a flood plain

Exposure indicator. Surface area of floodable developed land (return period of 500 years). The urban area, or developed land, is estimated as the sum of the areas with coverage consisting of expansions (UEN), town centres (UCS), discontinuous coverage (UDS) and buildings (EDF), multiplied by the percentage of coverage corresponding to these uses. These areas are cross-referenced with the area of flood plains, and we then calculate the sum of the area (in percentage urban coverage) of all areas recorded as urban which are completely or partially located in flood plains. Sources: Ministry for Ecological Transition (flood plains) and SIOSE Date: SIOSE (2014).

Monitoring: Requires updates from SIOSE to be monitored.

INDICATOR 221. Floodable surface area (Q100 and Q500) per municipality

Exposure indicator. The surface area of the municipality, in m^2 and as a percentage, which is located in a flood plain with a return period of 500 years. A static indicator, as the flood plains associated with each return period are not updated. Sources: Ministry for Ecological Transition (flood plains).

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INDICATOR 222. Cooling degree days

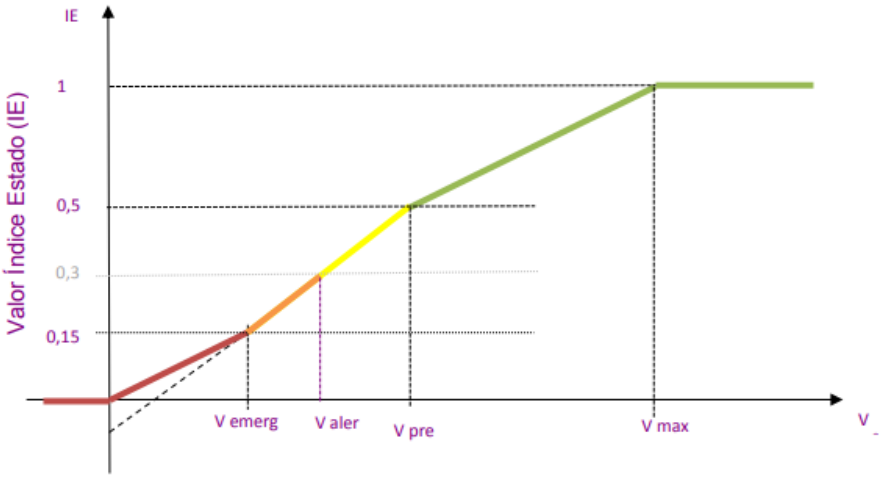
Impact indicator. This is a measure of the energy demand required to cool a building. It is calculated as the annual sum of TM - n (where n = 15.5°C and TM > n). The units are degree-days and the annual average is calculated for the periods 1961-1990 (historical climate) and 1991-2019 (current climate) based on observed data distributed across the grid, and 2021-2050 and 2051-2080 based on grid projections obtained from the AdapteCCa platform.

INDICATOR 223. Heating degree days

Impact indicator. This is a measure of the energy demand required to heat a building. It is calculated as the annual sum of n - TM (where n = 15.5°C and TM < n). The units are degree-days and the annual average is calculated for the periods 1961-1990 (historical climate) and 1991-2019 (current climate) based on observed data distributed across the grid, and 2021-2050 and 2051-2080 based on grid projections obtained from the AdapteCCa platform.

INDICATOR 224. Indicator for water scarcity per UTE (territorial unit of scarcity)

Impact indicator. The scarcity indicator is based on the relationship between resource availability and demand, identifying situations of circumstantial deficit in each of the defined territorial units of scarcity (UTE). Hence, once the UTEs and their characteristics and geographical scope are known, an iterative process is initiated, which leads to the calculation of one single indicator of circumstantial scarcity for each UTE. This indicator must be representative and explain the occurrence of circumstantial scarcity, reflecting one of the following categories: No scarcity (normality), moderate scarcity (pre-warning), significant scarcity (warning) or serious scarcity (emergency). In this dashboard, an indicator is provided for the number of months per year for each category in each UTE.



Sources: Ebro Water Confederation and Cantabria Water Confederation [131, 132]

Monitoring: Monthly.

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