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Executive Summary

RESIN is a 3.5-year EU-funded interdisciplinary research project investigating climate resilience in European cities that launched on 6 May 2015. The project combines existing approaches to climate change adaptation and disaster risk assessment to develop guidelines and tools to support cities in adapting to a changing climate.

Four city assessment reports written on the RESIN cities Bratislava, Bilbao, Greater Manchester and Paris will allow the cities as well as RESIN project partners to assess, which adaptation and critical infrastructure protection strategies, plans and measures are already in place or planned. It will also enable a better understanding of the options and decision-support tools and products that may best be suited to the specific local context of each of these four European cities and which of them might best be tested within the course of the project. It will also enable the local government, the stakeholders in the cities as well as the RESIN partners to better understand each city's needs in the adaptation and critical infrastructure protection process.

In this report, the general and more detailed features of the City of Bilbao are presented to showcase the context in which the local government can and does act in light of current and future climate change impacts. The reader gains insight into the demographic development of the city, its economic state, housing situation and its critical infrastructure characteristics (e.g., water supply, waste disposal, electricity). The information that is currently available – and necessary to understand and deal with the risks the city may be facing – will also be listed. Being aware of this, the reader is introduced to the City of Bilbao's plans and targets it has set itself to adapt to climate change and protect its critical infrastructure. It will also become clear, which stakeholders are currently involved and can push these issues forward. The city's political commitment as well as its legal and financial frameworks, which frame the city's planning activities are explained in detail thereafter. The reader is then presented with the actual measures the city as well as other stakeholders are already implementing. To conclude, the city's challenges, opportunities and achievements when it comes to adapting to climate change and protecting its critical infrastructure are highlighted. The city's needs to keep on adapting to climate change and safeguard its critical infrastructure are summarised at the end.

The reader will thus gain a comprehensive understanding of where the City of Bilbao is at currently, where it plans to head to and the context from where it is starting to adapt to climate change and protect its critical infrastructure.

For more information on the project partners, background and aims, please visit <http://www.resin-cities.eu/>

1 Introduction

Bilbao, the capital city of the province of Biscay in the Basque Country in the north of Spain, is a port city spread across 40.65 km². The city lies along a 16-kilometre-long estuary, embedded between two mountain ranges to the north-east and south. As the sea is not far away, Bilbao's climate is rather maritime with the tides still reaching the city. Bilbao may therefore be significantly affected by a changing climate.

This report will shed light on Bilbao's current features and future developments and how they are linked to and thus may be impacted by climate change. The reader will also get a brief overview of the plans and strategies in place that support adaptation efforts. Not only will the challenges the city is facing in adapting to climate change and protecting its critical infrastructure be summarized, the opportunities that lie within these changes will also be spotlighted. The report will summarise the challenges the city faces in adapting to climate change and protecting its critical infrastructure and will also highlight the opportunities these changes present.

The objectives of this report are to inform the decision-makers and planners of the local government on the existing data and information available to understand the impact a changing climate may have on Bilbao, the current plans in place, which solely or partly cover the field of adaptation and infrastructure protection, the challenges and opportunities the city is facing to better adapt and protect its critical infrastructure, and its need to better adapt and become more resilient overall.

The information collected for this report was provided by the RESIN partners of the City of Bilbao, mainly by the Department for Environment and the Department of Urban Planning, in collaboration with the RESIN partners at Tecnalía and BC3. The report itself was written by the RESIN partners at ICLEI – Local Governments for Sustainability in cooperation with the City of Bilbao.

2 Bilbao and its features

Bilbao has transformed immensely over the last few decades. This section outlines the social and economic changes as well as those in the housing and transport sector to illustrate how the city got where it is today. This information is also important to better understand where Bilbao's strengths and potential weaknesses may be in protecting its critical infrastructure as well as the city's ability to withstand and adapt to the effects of climate change.

2.1 Demographic development

Once a major industrial hub throughout northern Spain, Bilbao has had to deal with a declining population for the past two decades after an economic downturn led people to seek a new livelihood in other parts of the country or even Europe. Today, the city has a population of around 343,234 inhabitants, whilst the agglomeration is more than double the size with approximately 859,907 (2015)¹. The city is divided into eight districts (cf. Fig. 1), which again are sub-divided into overall 39 neighbourhoods.

¹ http://www.eustat.eus/elementos/ele0011400/ti_poblacion-de-la-ca-de-euskadi-por-ambitos-territoriales-segun-lugar-de-nacimiento/tbl0011425_c.html#axzz41AMQOVC9

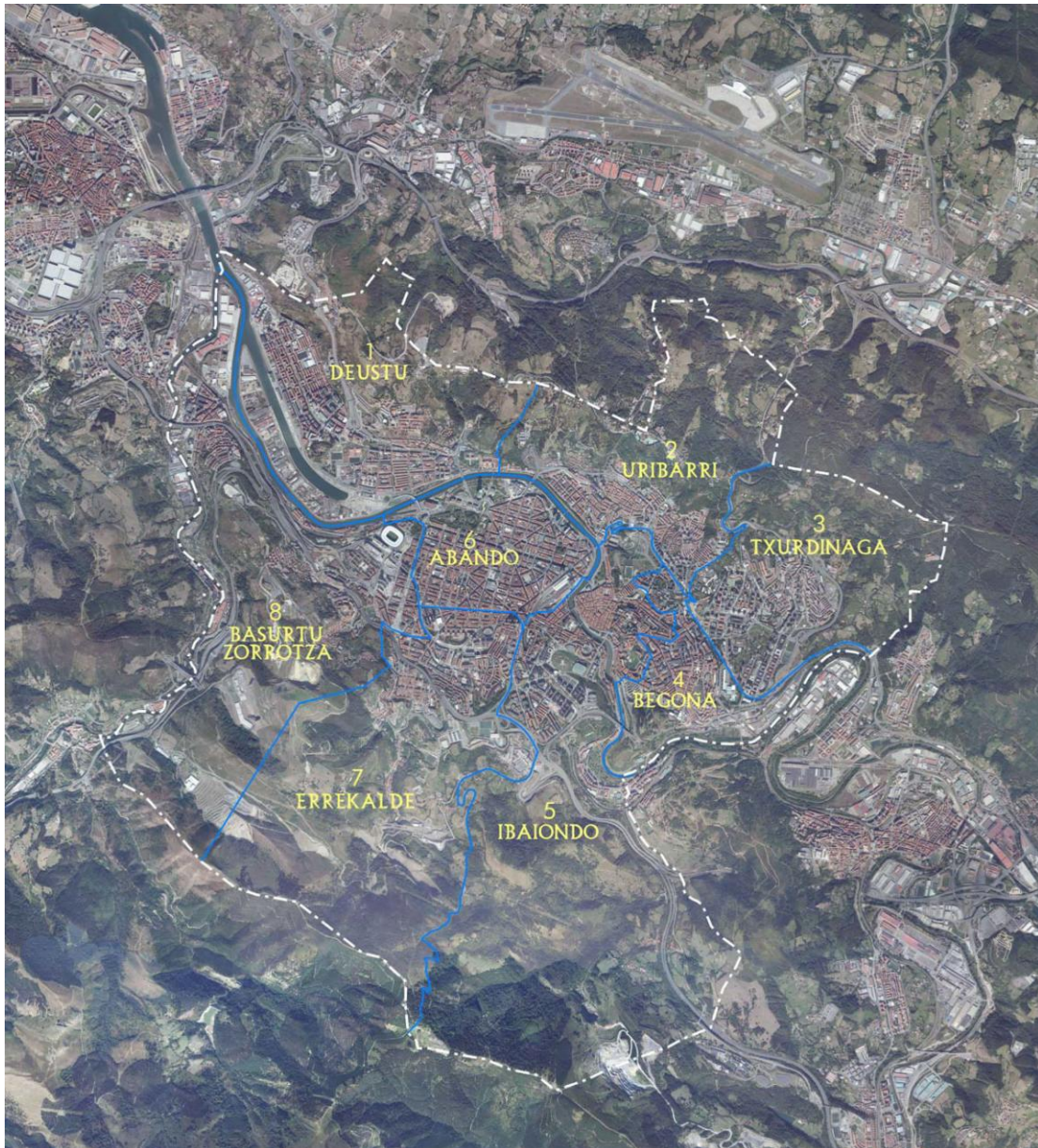


Fig. 1: Map of districts of Bilbao (Department of Territory, Municipality of Bilbao, 2015)

Forecasts suggest that the city of Bilbao will continue to lose inhabitants, leading to around 322,000 inhabitants in 2030. Bilbao will not only have to deal with a smaller population, but their average age will also increase – similarly to most other cities across Europe. The majority of people in Bilbao are between 45 to 64 years old. While the number of young people is already smaller and decreasing with a birth rate of 0.77%, the number of elderly people over 65 years old is increasing. The death rate is already at 10% and one in five people is older than 65 years old². The elderly, who are more likely to be

² Demografía y diferenciación socioespacial en Bilbao (2011), Estudios previos diagnósticos para el Plan General. Dpto. de Economía Aplicada I, UPV-EHU.

frail or have health issues, are far more vulnerable to extreme weather events, particularly heat waves. As there are also differences in the spatial distribution of the elderly across Bilbao, some neighbourhoods may be even more vulnerable than others merely from the perspective of the well-being and agility of their people.

The number of people with a migrant background also varies across the city. 7.5% of Bilbao's population have a migrant background. The main countries of origin are Bolivia, Colombia, Romania, Morocco and Ecuador³. Whilst many migrants also have Spanish as a mother tongue, which makes it easy for the local government to communicate their adaptation plans to these communities, it is important to involve them in developing and implementing these plans. Tailored awareness raising campaigns might be worthwhile considering, particularly if the districts they live in are the poorest, exposed to impacts (e.g., along the riverside or in the hillsides) and thus vulnerable to climate change impacts.

Bilbao as RESIN partner has already identified its most vulnerable groups of society. The most relevant impacts of climate change – heat, flooding and extreme weather events – affect children, the elderly, people with disabilities and low-income families the most. They do not have the means – physically, health-wise or economically – to sufficiently withstand these impacts. Yet, whilst these groups have been identified, there is further need to assess the extent of their vulnerability, their location in the city and agglomeration and the factors that enable and hinder them the most in becoming more resilient against increased climate risks.

2.2 Housing need

Although the number of people is declining within the city, there is still a high demand for housing space as most people from the metropolitan area wish to live in the city. More than 13.700 new housing units are therefore currently being planned in the city⁴.

To be able to deal with this housing pressure and protect these new housing units and the respective infrastructure around them from climate-related risks, the location of these new developments needs careful decision-making. Spatial analyses of climate change impacts may lend support in making the right decision. The city department for urban development still needs to issue such analyses and work closely together with the Basque Water Agency, which has shown an increasing interest in including the effects on climate change in its hydrological planning. In fact, the agency has produced river flood risk maps (RCP 4.5 and 8.5) for the estuary of Bilbao in the framework of the European Commission funded FP7 project Econadapt.

³ Demografía y diferenciación socioespacial en Bilbao (2011), Estudios previos diagnósticos para el Plan General. Dpto. de Economía Aplicada I, UPV-EHU.

⁴ Advance of Bilbao Urban planning. Urban Planning Office of . Bilbao City Council (2016).

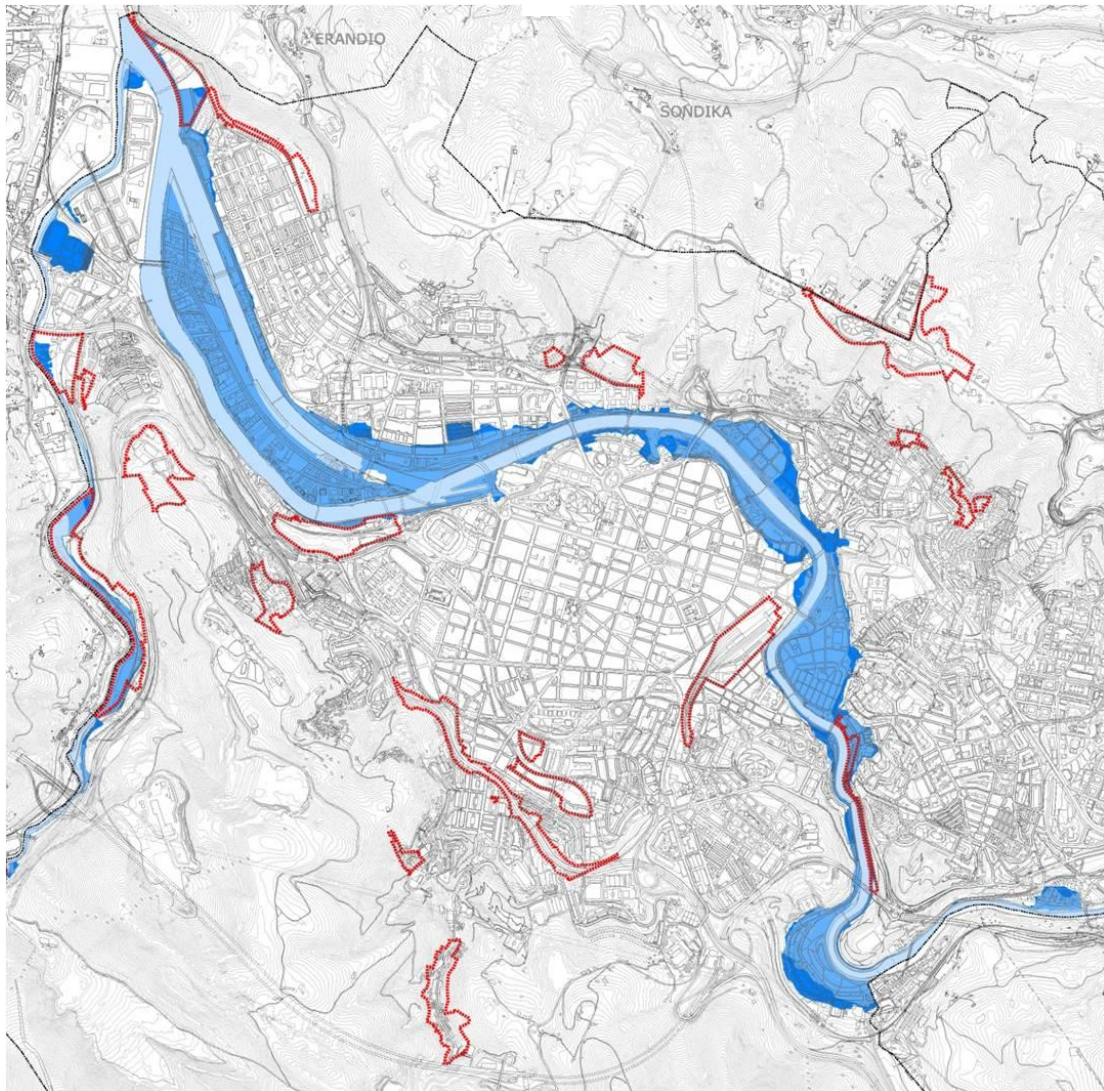


Fig. 2: Areas prone to flooding (from the Territorial Plan for Rivers and Streams, Basque Government, 2000)

2.3 Economic state

Climate change impacts can easily disrupt a city's economy. The local government of Bilbao therefore needs to help protect the infrastructure its economy relies on for the production and the provision of services to counteract any damages and losses.

This is particularly relevant as over the past decades, Bilbao's economy has found strength again. Today, the service sector (87.6%) dominates the local economy, whilst the industrial (6.9%), building (5.4%) and agricultural sectors (0.1%) have suffered losses in contributing to the city's annual Gross Value Added (2012). In 2012 the GDP per capita amounted to EUR 30,889 (2014). Yet, most of the service sector predominately relies on trade and repairs services (24%), followed by professional,

scientific and technical services (18%) and education services (18%) (EUSTAT, 2012)⁵. Many of these activities are based on knowledge and are mainly located in the city centre⁶.

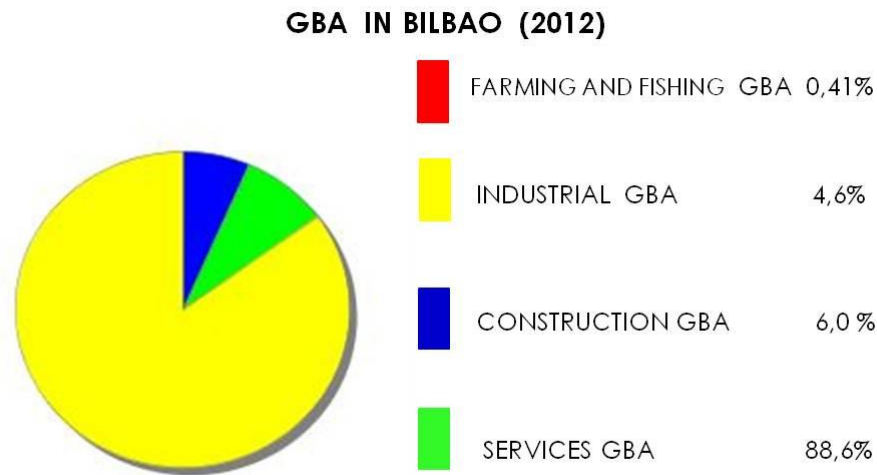


Fig. 3: Contributions per economics sectors in Bilbao (EUSTAT, 2012)

The number of gainfully employed in Bilbao ranges around 45.72% – a number which is still recovering from the industrial downturn from the 1980s onwards (the percentage of unemployed Bilbao residents' in Bilbao in 2014 lies at 14.02%). The manufacturing and construction sector are still the second and third biggest employing sector (ca. 24,000 in total) after the commerce, transport and logistics services sector (ca. 34,000 in total). Bilbao's transformation has also lead to more than 10,000 locals being employed in the tourism, hotel and catering services sector⁷.

The average income of a family in Bilbao is approximately EUR 40,806 (2014). The average monthly mean income is EUR 3,157 (2013)⁸. The local government needs to keep this number in mind as low-income families, which are also affected by family members becoming unemployed, may become even more vulnerable to climate risk.

2.4 Mobility

Bilbao's local government has introduced a number of activities to encourage its citizens to switch to more sustainable modes of transport over the past few years. Within the city centre, most people get around on foot (64%), whilst others opt for public transport (24%) or private cars (12%)⁹.

Still, there has been an increase of around 10,000 each of motorised vehicles and public transport

⁵ http://www.eustat.eus/estadisticas/opt_0/id_13/subarbol.html#axzz41B22lz6r

⁶ Plan de indicadores de sostenibilidad urbana. Agencia del Ecología urbana de Barcelona 2012.

⁷ http://www.eustat.eus/estadisticas/opt_0/id_10/subarbol.html#axzz41B2cSmv7

⁸ http://www.eustat.eus/elementos/ele0011100/ti_producto-interior-bruto-pib-per-capita-de-la-ca-de-euskadi-por-ambitos-territoriales-precios-corrientes-euros/tbl0011123_c.html#axzz41B2OIXUP

⁹ Estudio de Movilidad en Bilbao . Departamento de Circulación y Transportes. Ayuntamiento de Bilbao (2011).

between 2004 and 2008; a drastic increase to which the administration has had to respond. They have done so by defining measures in the city's Sustainable Energy Action Plan (SEAP) such as the extension of the tram and underground lines in the city, limiting the speed to 30 km/h in some areas and promoting the use of bicycles throughout Bilbao. While a further increase is probable, no data has yet been collected. At the same time in 2014 the number of bicycle loans amounted to 285,000 whilst the users of the city's public bicycle loaning scheme lay at over 18,000. Promoting climate compatible and friendly transportation modes could help Bilbao to mitigate climate change SEAP (Sustainable energy action plan of Bilbao 2020 approved in 2012).

2.5 Other critical infrastructure features

The transport and housing sector can be considered to be critical infrastructure. The Spanish set of critical infrastructure includes, amongst others, water and wastewater, energy, IT, food or even the financial sector.

Spain's national infrastructure is currently categorised into twelve critical sectors (CNPIC, n.d.):

1. Administration
2. Chemical Industry
3. Energy
4. Financial and Tax System
5. Food Supply Chain
6. Health
7. Information and Communication Technologies (ICT)
8. Nuclear Industry
9. Research Laboratories
10. Space
11. Transport
12. Water

In order to be able to assess the state of these infrastructures, the city of Bilbao still needs to define what it considers as its 'critical infrastructure'. To then be able to establish how vulnerable these sectors are towards climate change impacts, the city of Bilbao may want to compile its partial vulnerability assessments and exposure maps and conduct an overall assessment of its entire critical infrastructure. This would provide the local decision-makers and planners with data on which they could make decisions and design plans or strategies for protection and adaptation. So far aspects concerning critical infrastructure have partially been considered in plans dealing with other issues such as in the plan for new neighbourhood of Zorrotzaurre, which is about to be developed, and the Bilbao Emergency Plan.

The current state of some of Bilbao's basic infrastructure is sketched out as follows. To what extent this infrastructure is critical needs to be defined by the city's administration:

Water Supply

The water supply of the metropolitan area is set out in the North Hydrological Plan, which was prepared by the North Hydrographic Confederation. The confederation is managed by the Bilbao Bizkaia Water Consortium.

Bilbao has a complex water supply system, which is fed by the Zadorra as well as the Ordunte system. Another water reserve is the Zollo dam. In times of extreme drought other sources, particularly spring water, are used. Yet, the North Water Plan includes new measures such as the construction of dams (Herrerias and Altube) in two tributaries of the Nervión and Kadagua.

The city thoroughly measures and controls its water quality. Daily samples from the supply system across town as well as inspections and tests at the consumer side contribute to Bilbao's satisfactory quality of drinking water. It also means the city has an effective system of preventive monitoring.

Municipal Sanitation Network

In the seventies the high water pollution was one of Bilbao's the main problems. This pollution was mainly due to the uncontrolled dumping (both industrial and domestic). In response to this situation, Bilbao launched the Integral Sewerage Plan for the Bilbao Metropolitan Area in the mid-seventies. Thus, after 25 years of work and the investment of EUR 600 million, the city has minimised the effects of

sewage pollution stemming from the metropolitan area (internal city council information). This complex sewerage system serves nearly the entire population of the city – fewer than one thousand people remain to be connected to the integrated sanitation system.

The Department of Public Works of Bilbao has conducted an assessment of both the supply and sewerage systems. This analysis led to the proposal of a renovation plan for both systems. Currently, the city uses a GIS which allows the Public Works Department to get current information about the breakdowns and incidents in the city and to localise leaks.

Since 2000, it has invested more than EUR 54 million in works: EUR 28.3 million went into improving 71% of the supply networks. The sewerage system was improved with an investment of EUR 25.6 million to replace 25 kilometres of sewerage network, i.e. 3.9% of the overall network (internal city council information).

Waste Disposal Site “Zabalgarbi”

The company running the Zabalgarbi disposal site manages a solid waste-to-energy plant and also houses a mechanical biological treatment (MBT) plant, a composting plant, a landfill and a leachate treatment plant.

During construction of the first plant, Zabalgarbi regenerated and recovered the entire Artigas-Arraiz Special Plan area covering 108 hectares. The land was degraded by shaft mining activity and an open-cast quarry. Today the area has been reforested, trails were built and space provided for people to enjoy themselves in gardens, picnic areas and along forest tracks.



Fig. 4: Water supply and sewerage network (red lines represent the municipal network; blue lines the network of the Bilbao Bizkaia Water Consortium) and waste disposal site “Zabalgardi” (red area at left) (Town Planning Office, Municipality of Bilbao, 2015)

Transport

The model of the road network is designed as a functional radial access, a major road surrounding the city. This main structure distributes the traffic flows throughout the city in different levels (regional, national and international).

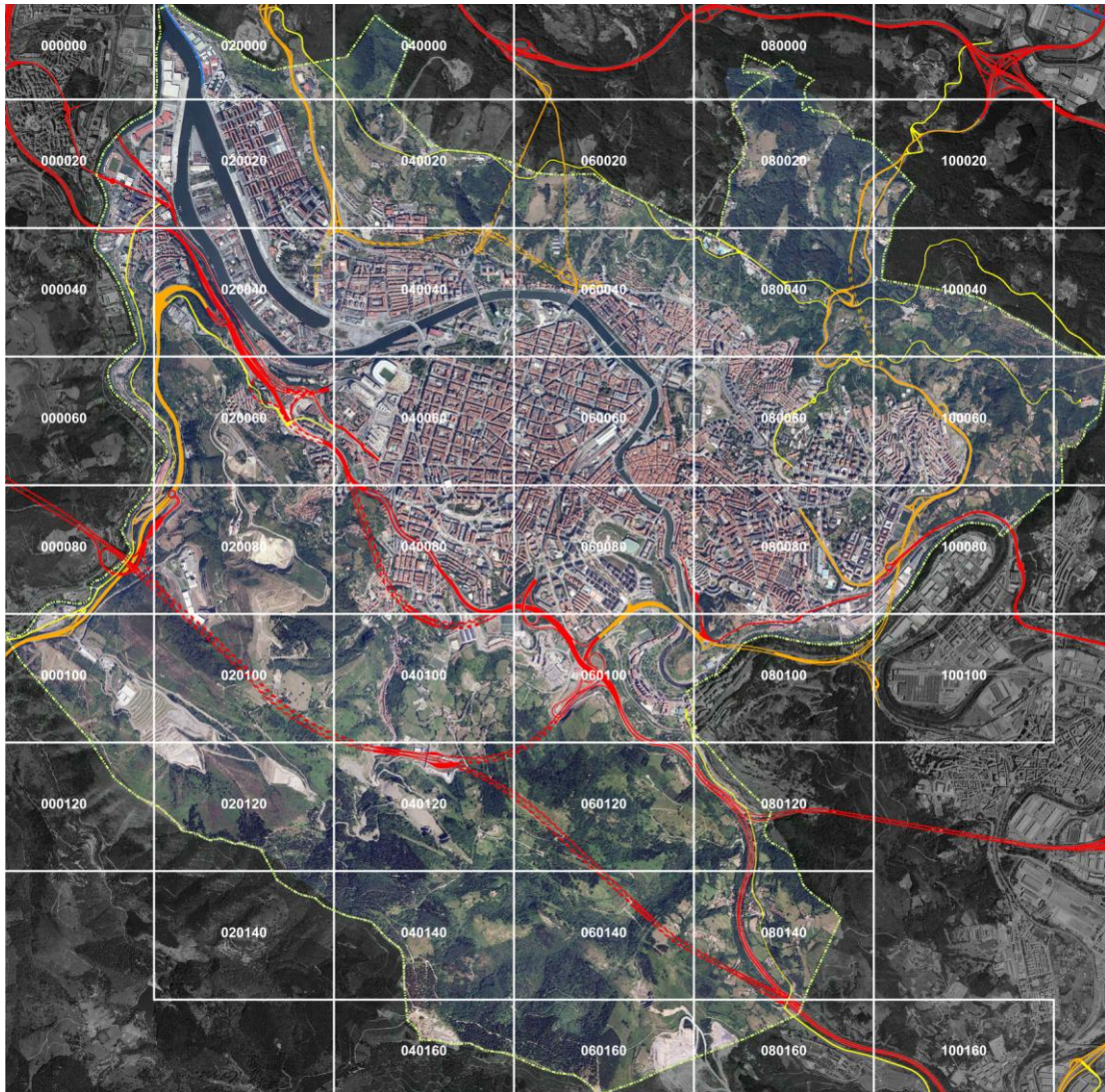


Fig. 5: Road network of the City of Bilbao (IDOM Engineers for the Town Planning Office, 2013)

In the municipality of Bilbao there are four rail operators: two managed by the Spanish Government (RENFE and FEVE) and two by the regional Government (Metro Bilbao, Eusko Tram, Eusko Tren).

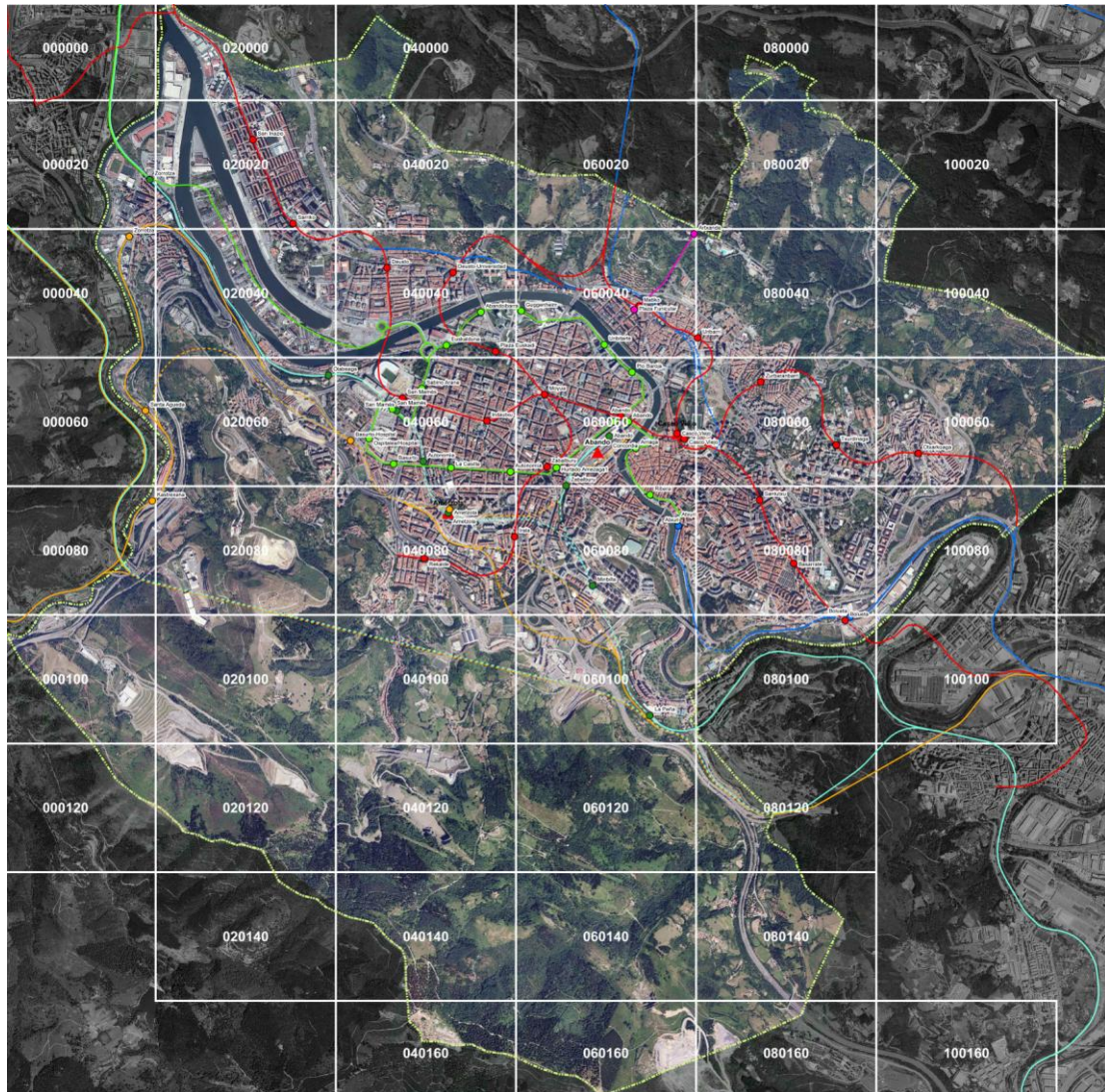


Fig. 6: Rail network of the City of Bilbao (IDOM Engineers for the Town Planning Office, 2013)

Energy

Responsibility for the city's energy infrastructure does not lie with the local authority. Renewables only cover 2 % of the total energy demand (Basque Government, 2013). The rest of the energy (i.e. electricity and gas) is supplied by private energy utilities which have a share in renewable energy production at the national level. The energy company that supplies most households in the city is Iberdrola S.A., which is also the company that is in charge of the energy services of the city.

The Public Works and Services Department of the City Council is responsible for the energy management of the city. While the Urban Planning Department is not currently involved in developing the city energy strategy, they are incorporating energy indicators into the New Urban Master Plan (Olazabal, 2014).

3 State of adaptation and infrastructure protection plans and activities in Bilbao

The city of Bilbao has already been affected by climate change and will continue to be in the future. The city has intensified and promoted the steps it has been taking to adapt to these changes. There are no efforts uniquely tailored towards protecting its critical infrastructure, but means to do so are integrated into other plans.

3.1 Baseline information and data to formulate plans and strategies

To be able to develop informed plans, a city needs to have a basic understanding of the status and development of its urban environment, the (potential) impacts of a changing climate and the vulnerability of its critical infrastructure. One way of appraising the situation is by means of a city-wide assessment of climate risks and vulnerabilities. While the local government of Bilbao has not yet conducted a complete risk and vulnerability assessment, it can draw on climate-related information from a handful of recent projects, studies and assessments. Amongst them are:

- **Assessment of the urban heat island effect**¹⁰: The urban heat island effect of Bilbao was modelled using the UrbClim tool on the scale of an urban agglomeration and its nearby surroundings and the Enviro-HIRLAM model (at micro-scale model). Another report investigated the impact of climate change on atmospheric pollution¹¹. Focusing on the urban area of Bilbao, and on the harmful pollutant PM10 (particulate matter), we developed a statistical scheme linking PM10 concentrations to climatic parameters readily available in climate projections. Once established for present-day conditions, these relations were applied to output from an ensemble of regional climate simulation results.
- **Design solutions for Urban Heat Island mitigation in the City of Bilbao**¹²: This study presents the results of a heat wave analysis in the city as part of the project in which as connection between the green belt and the city parts would lead to the reduction of the heat wave risk in Bilbao. Evaluations of wind behaviour through diverging temperatures as well as human comfort and heat stress in the urban areas of Bilbao were also undertaken. In addition, recommendations and design solutions for areas affected by the UHI effect as well as general guidelines on how to integrate the findings into the Bilbao master plan were given.
- **Policy and decision context of case studies**¹³: This document describes the contexts of the Vltava and Bilbao case studies, dedicating particular attention to the areas of policy and of

¹⁰ Published within the European Commission financed FP7 project RAMSES and authored by VITO and Tecnalía as D4.1 “Validation of agglomeration-scale climate projections” (2014).

¹¹ Published within the European Commission financed FP7 project RAMSES and authored by VITO and Tecnalía as D4.2 “Agglomeration-scale urban climate and air quality projections” (2015).

¹² Published within the European Commission financed FP7 project RAMSES and authored by NTNU and Tecnalía (2014).

¹³ Published within the European Commission financed FP7 project ECONADAPT and authored by Paolo Scussolini (VUA), Kateřina Kaprová and Jan Melichar (CUNI), Elisa Sainz de Murieta (BC3), Ibon Galarraga (BC3), Manuel Lago, Josselin Rouillard; Jenny Troeltzsch (ECOLOGIC INSTITUTE)

decision-making. For each case study the report presented the information about the geo-socio-economic context of each of the city's countries in general as well as the context at the local level (e.g., main issues, general and detailed research goals, policy and regulatory context as well as stakeholder constellations).

- **Description of adaptation options and their costs and benefits¹⁴**: This document contains a general catalogue of options for adaptation to an increasing flood-risk, presents the methodological approach to the cost-and-benefit analysis and examines adaptation measures that are currently in place or planned for the future for the two case studies in the Vltava river basin and the city of Bilbao.
- **Analysis of effectiveness of measures against the urban heat island effect¹⁵**: The effectiveness of a number of measures was assessed via the Envimet tool. This report contains the results of advanced numerical modelling and on-site measurements of the impacts of climate change adaptation on the urban climate.
- **Adaptation to Urban Floods by Planning and Design. Guidelines for an Adaptive Management to Urban Floods and Stormwater Use. A Case Study of the City of Bilbao¹⁶**: The study proposes a set of adaptive strategies and design solutions to manage floods and storm water in Bilbao from the perspective of an architect and urban planner to minimise the effects of the extreme precipitation and adapt to new climatic conditions while maximising the opportunities.
- **Climate change impacts of coastal and pelagic environments in the south-eastern Bay of Biscay¹⁷**: The analysis on the current sea level rise in the Bay of Biscay also indicates the situation in Bilbao and includes an increase in temperature accompanied by more frequent heat wave episodes, more intense and extreme daily rainfall as well as sea level rise.
- **Review of climate change losses and adaptation costs for case studies¹⁸**: The aim of this report is to provide an overview of climate change losses and adaptation costs in cities, particularly in the RAMSES case study cities in Bilbao as well as London, Antwerp, Bogota, Hyderabad, Rio de Janeiro and New York.
- **Analytical framework of the decision-making process on adaptation¹⁹**: The objective of this report was to provide an analytical framework to apprehend adaptation strategies implemented by cities, through at least four RAMSES city case studies - Bilbao, Bogotá, New York and Rio de Janeiro. The development of a framework was the first step in the analysis of the decision-making processes on adaptation, which will look at the diversity of the protagonists, their rationality, and

¹⁴ Published within the European Commission financed FP7 project ECONADAPT and authored by Paolo Scussolini (VUA), Kateřina Kaprová and Jan Melichar (CUNI), Elisa Sainz de Murieta (BC3), Alina Tepes (BC3), Ibon Galarraga (BC3), Josselin Rouillard, Jenny Troeltzsch and Manuel Lago (ECOLOGIC INSTITUT)

¹⁵ Published within the European Commission financed FP7 project RAMSES and authored by NTNU and Tecnalia as D4.3 "Urban Adaptation effects on Urban Climate" (2016).

¹⁶ Published within the European Commission financed FP7 project RAMSES and authored by NTNU (2014).

¹⁷ Published by AZTI Tecnalia (2011).

¹⁸ Published within the European Commission financed FP7 project RAMSES and authored by LSE & SENECA as D5.1 (2014).

¹⁹ Published within the European Commission financed FP7 project RAMSES and authored by UVSQ as D7.1 (2014).

the elements that structure their behaviour.

- Other research studies done are by the Basque Water Agency (URA) information on current river flood risks²⁰ as well as BC3 on flood damages and costs of opening the Deusto canal²¹.

Research results from the EU-funded project RAMSES, a project aimed at delivering quantified evidence of the impacts of climate change and the costs and benefits of a range of adaptation measures in, have shown that the main local climate risk factors are river and pluvial flooding (by far the most relevant risk), sea level rise, air pollution and heat waves.

River and pluvial flooding: Over the last six centuries Bilbao has been affected by 39 floods. Most of them occurred at the end of the 19th century as the river was reshaped and channelled. After those works finished the floods became less at the beginning of the last century. But a sprawling and more densely populated city, expanding industrial sites across the agglomeration and throughout the Nerbioi valley as well as insufficient dredging and maintenance works of the estuary led the floods to return from the 1950s onwards.²² Today, flooding is still the most common threat in Nerbioi valley, where Bilbao lies. A number of contributors are inadequate forest management, intensive cattle raising, damaging recreational practices – all three of which intensify erosion in the area – and Bilbao’s urban sprawl. Based on regional climate models predicting a 10% increase in extreme participation events across the Basque Country, the flooding threat will likely be aggravated. It was also estimated that the peak flow of the Nerbioi River in 2050 will have risen by 22%, which in turn could mean that the area at risk of flooding may expand by 3% (Mendizabal et al., 2013). While this figure sounds minor, it can have disastrous effects on adjacent housing, industrial areas and agricultural land. The costs incurred by the heightened flood risk of the metropolitan area of Bilbao may rise even more steeply by 56.4% in comparison to scenarios, which do not take account of climate change impacts (IHOBE, 2007).

Sea level rise: A rising sea level accompanied by higher tides will aggravate the flooding potential along the estuary with all the above mentioned consequences (Basque Government, 2011).

Air pollution: Air quality is the responsibility of the Basque Government, so that historical data is published and available on its website.

There are five information panels about air quality in the main entrances to the city:

- Juan de Garay
- Avenida Sabino Arana
- Rotonda del Euskalduna
- Puente de la Salve
- Rotonda Pío X

²⁰ See cartography in http://www.geo.euskadi.eus/s69-aguas/es?r01kQry=tC:euskadi;tF:opendata;tT:ds_geograficos;CA:r01epd011efe71175952314cdc3cb053e6d4aabce;pp:r01PageSize.50;p:Inter_portal,Inter

²¹ Published by BC3 and authored by Osés Eraso, N., Foudi, S., Galarraga, I. (2012)

²² Published by EU RAMSES project, NTNU “Adaptation to urban flood by planning and design (2014).

Based on projections of the concentration of pollutant PM₁₀ for Bilbao, it was found that towards the end of the century, when considering the effect of climate change alone (i.e. assuming no changes in the emissions), PM₁₀ concentrations are expected to rise by approximately 0.3 µg m⁻³ during the summer, and to decrease by 1.1 µg m⁻³ during winter. The results indicate that climate change could have substantial effects on air quality in urban areas and as a consequence on human health, agriculture, and natural ecosystems. Changes in local climatic variables such as temperature, radiation, specific humidity, wind patterns and precipitation affect the different components of the pollutant life cycle and therefore affect the pollutant concentration (RAMSES D4.2).

Heat waves: The average temperatures during the summer months as well as winter seasons are forecasted to increase. In winter the increase will be starker with 1.1 °C during 2020-2050 and 2.5 °C in 2070-2100. Summer temperature increases during the same periods will lie around 0.7°C and 1.6°C respectively in comparison to today's situation (Gonzalez-Aparicio, 2013).

In addition to all of the abovementioned studies and forecasts, which were designed and completed by third parties, the municipality of Bilbao has defined and mapped its emergency response procedures and responsibilities within the city.

One of the regional bodies, the Basque Water Agency, has also begun to analyse and consider climate change in their flood maps.

In order to be able to collect more information and data on the current and future situation, the local government may need to make climate change adaptation and critical infrastructure protection a political imperative and define its research needs and open questions further. Having this information is the basis on which to develop an adaptation strategy.

3.2 Existing plans and targets for climate change adaptation and critical infrastructure protection in Bilbao

Over the past two years, the regional and national government of the Basque Country and Spain have issued policies and plans in support of climate change adaptation. At the Basque regional level the most recent plan is the "Climate Change Strategy for the Basque Country to 2050", which was issued in 2015 (Basque Government, 2015). In line with international commitments the strategy contains three objectives: (i) to reduce GHG emissions in the Basque Country by at least 40% in 2030 and by at least 80% in 2050, with respect to 2005, and (ii) to achieve 40% renewable energy consumption out of the final consumption by 2050 and iii) to ensure the resilience of the Basque territory to climate change (Basque Government, 2015). Whilst all Basque municipalities were asked to participate in developing and implementing it, the city of Bilbao itself is still at the start of its adaptation process. Recently, the Basque Country has presented an application ("Climate change strategy of the Basque Country to 2050 and its implementation at local level") to the Transformative Actions Programme and Compact of Mayors initiative initiated by ICLEI – Local Governments for Sustainability (internal municipal source). Bilbao will pilot approaches to climate change adaptation, focusing its efforts on addressing the flood impacts both from fluvial sources and sea level rise.

Necessary data and information already exists amongst a number of local and national research institutions. However, there is still no full set of information available as to where, when and to what

extent the city of Bilbao and its critical infrastructure are vulnerable to the effects of climate change. With such a comprehensive picture still missing, the city of Bilbao does not have its own stand-alone adaptation and critical infrastructure protection strategy or action plan – yet.

Nevertheless some aspects of climate change adaptation and critical infrastructure protection are already acknowledged in selected policies and plans adopted by the local government. Amongst such plans recognising adaptation –albeit not exclusively – are:

Zorrotzaurre Master Plan

The quality of life in the Zorrotzaurre neighbourhood had been on a continuous social and industrial decline since the 1970s. Many people left and at its bleakest scarcely 500 people were still living on the peninsula along the Deusto River. Today, it is the city’s biggest regeneration project. Having changed the designated usage from an industrial to a residential area already in 1995, a master plan was drawn up in 2004 and revised in 2007. It stipulates the opening up of the Deusto Canal, making the Zorrotzaurre peninsula into an island.



Fig. 7 and 8: Deusto Canal and Zorrotzaurre peninsula before and after the implementation of the master plan (BC3, 2012)



Fig. 9: Green zones along the newly planned Deusto Canal (Zorrotzaurre Regeneration Commission, 2015)

Opening up the canal and greening its banks would result in the river water being able to flow through, carry more volume and thus minimise the risk of flooding significantly. The RESIN partners from BC3 analysed the impact the new structure may have on the extent and frequency of floods. The 10-year return period for expected flood events will no longer apply resulting in a 100% reduction in expected costs. For the 100-year return period, the estimated damages will be reduced by 67.42% (from EUR 241.34 million to EUR 78.62 million). For the 500-year return period the cost reduction may account for 30.70% (from EUR 444.30 million to EUR 307.91 million) (Osés et al, 2012). The annual flood probability will also decrease significantly.

The Zorrotzaurre master plan also stipulates three more measures to be implemented. The construction of two storm water tanks along the riverside in San Ignacio between 2017 and 2018 at a cost of EUR 1 million, and one along the Deusto side from 2019-2020 at a cost of EUR 4.4, will further help reduce the flood risk. In addition, the construction of a flood protection wall along both riversides will help protect the existing and new housing along the river (Sustainable and Integrated Urban Development Strategies of Bilbao as internal municipality plan 2016).

Bilbao Emergency Plan

Bilbao City Council has adopted an emergency plan for the city, which is to be updated on an annual basis by the municipal sub-area for prevention, which includes the Civil Protection and Fire Fighting as well as the Public Safety units. A yearly update allows the quick deployment of financial resources and capacity across the city in the case of an emergency. The emergency plan is based on a geographic information system (GIS) through which risks as well as the severity and scope of an alert can be analysed throughout the city and the resources necessary to get the situation under control can be identified. It makes a swift response possible. The alert types considered in the emergency plan are, for example:

- Torrential rains and floods
- Avalanches

- Heavy snowfall and cold waves
- Gales and high winds
- Infrastructural collapse
- Road accidents
- Breakdown of services

The emergency plan helps prevent and reduce the impact of the threat as well as the effective and immediate management of the emergency. Linked to the GIS is a catalogue of the resources available, a list of telephone numbers and emails of people who are responsible for managing them. The city's emergency management is done in close coordination with the heads of other relevant departments such as the Departments for Security, Works and Services, Traffic and Transport, Public Space and Health, and Consumer Affairs. All emergency actions are directed by the Crisis Management Board and are supervised by the Mayor's office.

The extent to which adaptation and critical infrastructure protection is also considered in further municipal plans and strategies has yet to be identified and streamlined – for example, in a new climate adaptation plan.

3.3 Actors active in and relevant for CCA planning and CI protection

To develop climate change adaptation and critical infrastructure protection plans and strategies the city needs a sound understanding of all the organisations, companies, agency and authorities as well as citizens that have a stake in adapting to climate change and protecting Bilbao's critical infrastructure.

It is necessary to identify those actors that can either contribute to and/or are vulnerable to climate change impacts on critical infrastructure, as is the case for those actors that (critically) depend on CI services.

Actors within the local government – Making CCA a political priority

With each new election period, the organisational structure of the local government changes slightly. The current local government – elected in 2015 – is structured along six topical fields, which are subdivided into smaller areas of responsibility (cf. Fig. 10).

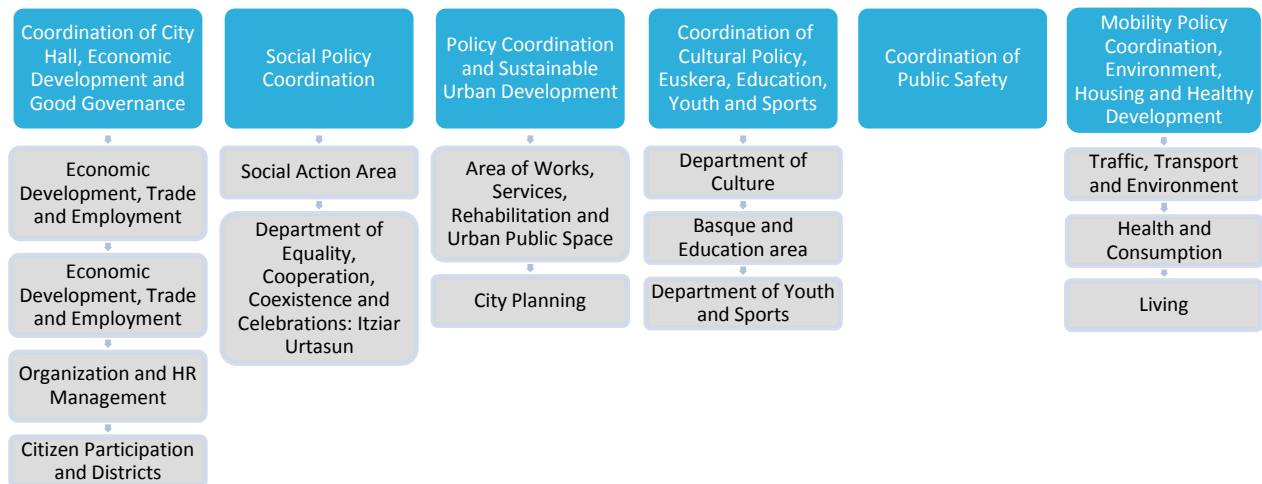


Fig. 10: Organisational structure of the local government elected in 2015 (City of Bilbao, 2015)

Not all of these departments are equally involved in making decisions and developing plans for CCA or CIP. Yet there are a number that could shape a new policy and plan, but the municipality does not have a set mechanism for how all relevant departments working on CCA can collaborate systematically. Those that are currently involved are the Departments for Policy Coordination and Sustainable Urban Development, the Environment, Housing and Healthy Development, the Mobility Policy Coordination as well as the one for Coordination of Public Safety.

Those departments that are already involved in the RESIN project are next to the Mayor’s Office are the Department for Environment, Civil protection, Public Works, Mobility and Urban Planning. They are and could be the drivers of Bilbao’s climate adaptation process.

Other departments and non-departmental bodies that will need to deal with the impacts of climate change as part of their everyday work are the municipal Departments for Health, Social Services, Citizen Participation and Environment and Territorial Policy. All of these departments should be engaged – if they not already are – in developing Bilbao’s climate adaptation and critical infrastructure protection plans.

Actors in Bilbao and its agglomeration – Joining forces on the ground

Similarly to the municipal departments just mentioned, there are other private public sector actors that should be involved as they operate and plan critical infrastructure and/or are already affected by climate change impacts. The most important stakeholders here are URA (Basque Water Agency), Euskalmet (Basque Meteorology Agency), DBF (Provincial Government of Bizkaia: transport, roads), IHOBE (Basque Environmental Agency), and the Bilbao Bizkaia Water Consortium.

The RESIN partners in Bilbao have also identified additional actors who indirectly influence or can contribute to advancing the city’s adaptation efforts. From the municipality side there are the Department for Economic Development as well as the one for Tourism.

Identified actors in the private sector are Euskaltel (telecommunications company), Iberdrola (energy company) and Gas Natural (gas company).

At the regional government level, the Provincial Council and Basque Government Departments play a major role in supporting Bilbao's adaptation efforts.

3.4 Political commitment and decision-making for adaptation and critical infrastructure protection

Giving the topics of adaptation and critical infrastructure protection a more prominent place within the local government and streamlining the decision process in favour of promoting adaptation and political commitment go hand in hand.

It is imperative that the city government, its political leaders and its administration align their priorities and reinforce their commitment towards both topics beyond election periods now to prepare Bilbao for future climate change impacts and make Bilbao more resilient. Whilst climate adaptation and critical infrastructure protection are as issues not directly addressed yet, the regional governments' efforts – both from the policy and legal side through the new strategy – support the local endeavours in this regard strongly.

Despite not having officially formulated a political commitment yet, the Bilbao local government is slowly showing that they are committed by signing a number of international commitments on climate change adaptation. Bilbao has, for example, just signed the Compact of Mayors. This entails the voluntary commitment towards mitigation and adaptation to climate change, and to report the city's progress and achievement of the objectives on a consistent basis to the public through recognized and legitimized platforms. The city council has also allocated a budget for departments to collaborate with research institutions and projects on climate change adaptation. RESIN presents such collaboration.

Political commitment provides a way to make the decision-making process supportive of planning and implementing measures of adaptation and critical infrastructure protection easier – and hopefully more cohesive amongst all stakeholders. While it is important to involve a wide range of them in the process, it is vital to first of all understand how, where and by whom decisions influencing the adaptation agenda are made.

In the municipality of Bilbao, such decisions are made during weekly meetings of the municipal government. Subsequently, they need to be approved by the city council. In addition, a monthly plenary session provides the opportunity to raise and discuss important topics. To enable a strategic and integrated way of making decisions towards adapting to climate change and protecting vital urban infrastructure, the local government could strengthen the cooperation amongst its departments by developing a coordination team or unit dealing specifically with these two topics.

When it comes to capacity for making decisions, planning and managing critical infrastructure protection, the responsibilities are a bit clearer. The bodies responsible for:

- water supply are Bilbao Bizkaia Water Consortium and public services departments of Bilbao City Council.
- energy and gas system are private companies such as Iberdrola, Gas Natural, and public services departments of Bilbao City Council

- urban roads is Bilbao City Council and the Provincial Body of Bizkaia (responsibilities are divided amongst these actors for road sections)
- regional roads is Regional Council of Bizkaia

3.5 Legal framework for planning and implementation

Yet, while a local government can do much to put adaptation on its list of, the legal and regulatory framework can dampen its efforts. However, both the Spanish national government and the regional government of the Basque Country have been very active in this field over the past years.

The Ministry for the Environment of the Government of Spain issued a Spanish Strategy for Climate Change and Clean Energy back in 2007 laying out its plans until 2020 (Ministry of Environment, 2007). The Basque Country has now followed and adopted the Basque Climate Change Strategy 2050 in 2015. Whilst the implications of the latter for Basque municipalities are yet to be seen, both strategies provide an incentive to do more at local level.

3.6 Financial framework for planning

The national and regional frameworks not only provide guidance from a legal point of view, but are also accompanied by the allocation of financial resources to implement measures. The Basque Country has a budget for adaptation activities at regional level of EUR 220 million for the period 2016-2010 (Basque ClimGovernment, 2015). This budget has been allocated to achieve a number of targets from increasing the Basque territory's efficiency and resilience, the resilience of the natural environment as well as the primary sector, to reducing emissions and anticipating changing risk. Yet, Bilbao has not been assigned a budget based on this regional strategy yet. Neither has the national policy allocated funds for local adaptation activities.

3.7 Communication throughout planning processes

If a city wants to achieve its ambitions, it needs to communicate them and engage all actors in the city to join in. Communication strategies surrounding adaptation are usually connected to official plans and strategies of a city. In Bilbao there is no unison message promoted by the political leadership so far, whilst a range of the departments are already involved in measures related to adaptation and critical infrastructure protection – directly as well as indirectly.

Yet, the need to adapt to climate change and protect critical infrastructure across the region is promoted by the Basque Country government as part of their Climate Change Strategy 2050. All of the monitoring and evaluation processes outlined in the regional strategy will follow a participatory approach amongst private and civil society organisations. The strategy's progress will be disseminated through a number of channels down to the local level where citizens will be encouraged to join and follow fora like Klima-Tex, the Udalsarea 21 network, the social barometer of climate change as well as the portal Basque Government website (www.klima2050.eu). This may also influence the local government's efforts in communicating the impacts of climate change as well as the need and benefits of adaptation and critical infrastructure protection across the city.

4 Implementation of adaptation and critical infrastructure protection measures

While the local government of Bilbao has not developed an adaptation strategy and measures to follow yet, the administration as well as the Bilbao Bizkaia Water Consortium have already taken charge and are in the process of implementing a handful of activities:

The City Council has authorised the opening of the Deusto Canal as part of the Zorrotzaurre Regeneration Project, which will mean the river level will be decreased by one metre to help prevent flooding (Saitec, 2007).

The Bilbao Bizkaia Water Consortium has on the other hand invested EUR 33 million and built a storm water tank in the district of Etxebarri with a capacity of ca. 75,000 m³, which will also help prevent flooding. The latter is also a means of protecting Bilbao's critical water infrastructure. A further two storm tanks are being built in the process of the Zorrotzaurre redevelopment (Sustainable and Integrated Urban Development Strategies of Bilbao 2030, 2016).

The outskirts of Bilbao are in danger of landslides during heavy rainfall. This risk will increase once the predicted more frequent and intense rains become a reality. The city council has therefore been supporting the reforestation of the slopes at whose feet the city lies. Since 2007 more than 41,000 trees have been planted. The city made sure that the varieties of species were also mixed and ready to withstand a changing climate (internal municipal sources).

With a future adaptation plan and strategy for protecting the city's critical infrastructure, these and many more implementation measures can be aligned and realized jointly using synergies and addressing a wide range of issues, which currently make Bilbao less resilient to climate change.

The main players involved in implementing measures are the City Council as the local administration and the Basque Water Agency as the planning and implementing agency.

4.1 Financial framework and incentives for implementing measures

There are a few financial incentives available from the national, regional or local level for the local government itself or other bodies or actors wishing to implement measures of adaptation and critical infrastructure protection.

The Bilbao City Council has applied for funding for its activities in Zorrotzaurre, within its Sustainable and Integrated Urban Development Strategy, in the framework of the European Structural and Investment Fund, mainly for the construction of two storm water tanks (2017-2018 for EUR 1 million) and along the Deusto side (2019-2020, EUR 4.4 million) to further reduce the flood risk. In addition, the construction of a flood protection wall along both riversides is being financed through these means (Sustainable and Integrated Urban Development Strategies of Bilbao 2030, 2016).

4.2 Communication and evaluation of the implementation processes

Similar to the planning process, there is no official strategy for the implementation process. Once Bilbao develops its adaptation as well as critical infrastructure protection plans, it should also develop a monitoring and evaluation mechanism to keep track of and improve the planning and implementation activities.

For the measures implemented, the respective municipal department either communicates the planning intentions as well as the type and timeline for the implementation to the citizens. While these messages do not per se include adaptation, they do involve the topics of critical infrastructure protection through flood protection.

5 Bilbao's challenges, opportunities and achievements in adapting to climate change impacts and protecting its critical infrastructure

Although the local government is demonstrating its motivation to address adaptation and critical infrastructure protection with all its complexities, the city needs to work on overcoming challenges in both fields.

With regards to getting the adaption process underway and implementing critical infrastructure protection measures, the city is finding it difficult to allocate its **limited financial resources**. A study undertaken by the RESIN partners of BC3 (Olazabal & Pascual, 2015) serves to confirm, that in the field of climate change mitigation one of the main barriers is the lack of funding available to restructure the city's energy model. This in turn blocks innovative ways of starting an energy transition process. Given the lack of initiatives regarding climate adaptation but the clear commitment of local and regional authorities to this issue, the same could be applied to this sector. It also suggests that the country's austerity and local fiscal budgets should not preclude action – once all relevant parties agree that action is necessary. Once all stakeholders are on the same page, they could contribute to Bilbao's efforts of transforming its social and economic structures and making the city resilient to future climate change impacts.

Adaptation as a topic is also **anchored and coordinated at local, regional as well as national government level**, which means a number of policy-making and planning bodies need to find common ground and develop coherent plans and measures to advance the adaptation process. Whilst the regional government has taken a strong lead in climate-proofing the Basque country, the local government needs to expand its political leadership. The signing of the Covenant of Mayors and the development of a Sustainable Energy Action Plan are a step in the right direction to kick-off a transition process towards a climate-resilient city. Bilbao also has just signed the Compact of Mayors and participated in the development of the Basque Strategy for Climate Change 2050. The latter strategy will also promote integrating mitigation and adaptation issues. If the local government manages to make use of the momentum and **develop a holistic vision of the adaptation process** across all areas of responsibility and sectors, the city could turn into a true climate leader.

When it comes to Bilbao's critical infrastructure, some of the obstacles relate to **protecting in particular its water supply and sewage system, energy supply as well as the transport system**. The responsible bodies as well as the political leaders must ensure that the operation of these infrastructures is still possible to the extent that the **city's, citizens' and private sector's fundamental needs can be met in case of emergency**. This means the local government needs to organise itself in such a way that it is able to upgrade and safeguard its existing infrastructure as well as be **able to invest in new and substantial infrastructure works**.

While the local government of Bilbao can and needs to set the tone and develop a strategy to overcome its current challenges in the adaptation arena, its citizens play a vital role in supporting and driving the

process forward. Yet, the RESIN partners from BC3 discovered in their study (Olazabal & Pascual, 2015) that there is a lack of understanding and awareness, frequent scepticism and even denial among the city's citizens. A lack of information on climate change impacts, the details of Bilbao's population and the infrastructure necessary to keep the city running may be contributing factors to this public opinion. One way to dispel such views and foster a positive, supportive attitude to the city's efforts is to educate people on cost-effective methods of reducing risks like flooding and hot spots as well as proving the co-benefits of climate action (Olazabal & Pascual, 2015). It was also shown that their citizens need to be involved from the very early stages of urban planning, so that they are aware of the problems the administration faces and so that the city administration is made aware of people's needs and suggestions.

Addressing Bilbao's challenges collaboratively is the key to turning them into opportunities for the city of which there are many. Not only could Bilbao gain from the numerous co-benefits of adapting to climate change across many of its sectors such as the local economy, society, urban development and the city's standing at national and European level. Adapting to climate change could also help prevent more flooding to which the city is vulnerable as evidenced by numerous flooding events over the past decades. By opening the canal, which flows through parts of the city, the administration has already begun to take advantage of this opportunity. While implementing adaptation measures is never a smooth job, Bilbao's size is an advantage in terms of the investment, planning and coordination efforts necessary. Being a medium-sized city also means that the results of the adaptation and infrastructure protection measures are visible more quickly.

Bilbao has had a strong industry for many decades and there are still a fair number of companies located in the city that have the expertise and capability to help the local government upgrade and adapt its infrastructures be stronger and climate-proof in the face of more extreme weather events.

6 Bilbao's needs for adapting to climate change impacts and protecting (critical) infrastructure

Based on the challenges it is still facing, the local government of Bilbao has rated its needs for better adaptation to climate change and to protect its critical infrastructure – mainly being water, energy and transport – as depicted in this Fig. 11:

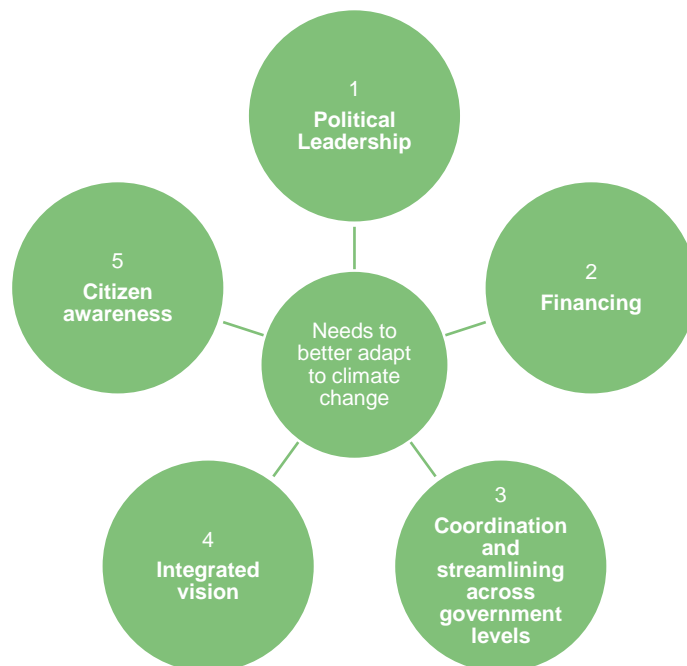


Fig. 11: Bilbao's needs to improve adaptation efforts

1. **Political Leadership:** Strong leadership is needed in climate change policies in order to actively involve all of Bilbao's key actors. The central and local government bodies are the ones who must assume this leadership in order to lay down specific guidelines for the city council's various responsibility domains.
2. **Financing:** A proper budget is required in order to implement the adaptation measures. The government and other interested parties need to look for different funding solutions to allow more investment in adaptation.
3. **Coordination and streamlining across government levels:** There are different public administrations with concurrent territorial jurisdiction as water, waste, energy, etc. For this reason, there is a need for proper coordination.

4. **Integrated vision:** An integrated urban planning vision that facilitates a good climate adaptation policy is necessary. This vision needs to include the urban ecosystem in its entirety, from the physical elements of the city to the behaviour of its citizens.
5. **Citizen awareness:** Citizen awareness is essential in the development of the adaptation policies. For example, public awareness will allow the effectiveness of municipal emergency plans.

The local government of Bilbao has also rated its needs to better protect its critical infrastructure. Their needs in this domain are actually very similar to those for climate change adaptation as Fig. 12 shows:

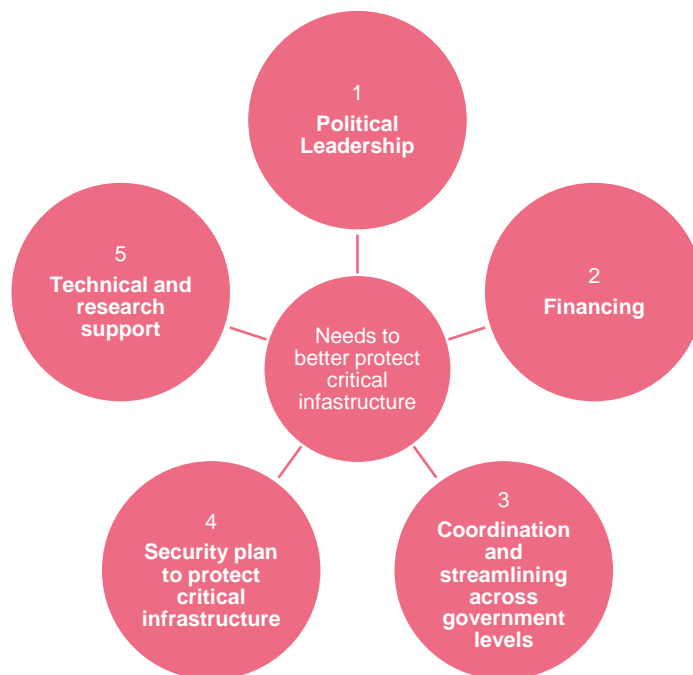


Fig. 12: Bilbao's needs to improve its critical infrastructure protection

1. **Political Leadership:** Strong leadership is needed in climate change policies in order to actively involve all of Bilbao's key actors. The central and local government bodies are the ones that must assume this leadership in order to provide specific guidelines for all city council responsibility domains.
2. **Financing:** A proper budget is required in order to implement the adaptation measures. The government and other interested parties need to look for different funding solutions to allow more investment in adaptation.
3. **Coordination and streamlining across government levels:** There are different public administrations with concurrent territorial jurisdiction as water, waste, energy, etc. For this reason, there is a need for proper coordination.

4. **Security plan to protect critical infrastructure:** An analysis of the city's vulnerabilities and the location of major infrastructure is required in order to find alternative solutions ensuring the provision of basic services in the case of catastrophic events.
5. **Technical and research support:** In an uncertain field such as climate change it is necessary that the scientific community supports the validity of the decisions made in urban climate adaptation, in order to substantiate the decision's validity.

Through RESIN, Bilbao hopes to create a sound evidence base by analysing its vulnerability towards climate change. Having a proper overview and knowledge of what the current situation looks like and what the forecasts are, the local government can develop an effective and efficient climate adaptation plan. Here local decision-makers will have to work together with the administration as well as its citizens, companies and research institutes. Being part of RESIN will allow Bilbao to gain from its research results, policy recommendations and have their research needs met to take further steps towards being a resilient city.

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