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Climate change related risks, opportunities and adaptation actions in European cities – Insights from responses to the CDP cities program

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Abstract

Cities, home to more than half of the world's population and important economic hubs, are vulnerable to climate change and worthy to protect. To address these challenges, implementing adaptation measures is inevitable. The paper provides insights into climate change related risks, opportunities and adaptation actions based on responses by 40 European cities to the 2014 CDP Cities Information Request.

The analysis shows that 92.5% of the responding European cities report that they face physical risks arising from climate change and that they identify *more intense rainfall* as the most relevant physical risk. Furthermore, more than half of the participants indicate that they are facing social risks due to climate change with *increased risk to already vulnerable populations* being the most important one. However, 72.5% of the cities report that they see economic opportunities arising from climate change. Already, 55% of the observed European cities indicate that they have implemented adaptation action plans and 82.5% of all cities are putting adaptation action into practice.

City governments show great awareness, interest and knowledge in addressing climate change issues, yet there is still demand for information and guidance. Moreover, the variety of answers shows that there is no "one-size fits all solution" for cities to adapt to climate change. Thus, the findings can also serve as an innovative starting point for further research as well as the practical implementation of adaptation measures.

Keywords: adaptation actions, adaptation planning, CDP, cities, climate change, climate change adaptation, climate change opportunities, climate change risks.

JEL-Classification: H11, H41, Q54, Q58, R50.

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1. Introduction

The impacts of climate change challenge regions, cities and municipalities, whereby responding to climate change involves both mitigation to address the cause and adaptation as a response to the changes (IPCC 2014). Local councils are key actors when it comes to the implementation of adaptation measures in order to improve the overall resilience of local territories in various fields such as water, energy, health and transportation. In doing so, local authorities are embedded in a frame of legislation, different (and conflicting) interests, missing or incomplete knowledge of climate change and its impacts. Increasing cities resilience to climate change impacts, thus, is highly context specific. It is not only the city's specific vulnerability due to its geographical location, structure, inhabitants and operational capability that needs to be taken into account. Equally important is the consideration of the individual backgrounds and interests of the stakeholders involved in the process of adaptation (Bender et al. 2015; Cortekar et al. 2015).

Consequently, the process from planning a measure until its implementation is time-consuming and requires various resources. The selection of proper adaptation measures is not easy either, as it is not possible to find the "one-size fits all adaptation" or the "universal best-practice example". It is necessary to identify local needs, because adaptation measures need to be tailored to the specific purpose (Bender et al. 2014). There are different ways to select adaptation measures for a municipality. One possibility is the use of an adaptation data base, where many adaptation activities are developed and tested in scientific projects. Another option is to take a look on flagship projects that are often used as best practice examples (Bender et al. 2014; Bender et al. 2015). An additional source is information on adaptation actions of similar cities in a similar region. The CDP's cities program provides such kind of information. It is a voluntary climate change reporting platform for city governments, open to any city government, regardless of size or geographic location, and currently used by over 200 cities across the globe. It is the world's first global platform for municipal governments to disclose greenhouse gas emissions, climate change risks and adaptation strategies and delivers materially relevant data for cities, the private sector, and other stakeholders. While city governments and public companies are vastly different in size, scope and structure, the annual disclosure cycle of CDP can offer an important impetus for cities to measure and report their climate change related information (CDP 2014).

"The CDP (formerly known as the Carbon Disclosure Project) is a not-for-profit organization for creating lasting relationships between various stakeholders regarding the commercial and non-commercial implications of climate change" (CDP 2014, p. 4). CDP aims to change the

global economic system in order to prevent dangerous impacts of climate change and to value natural resources. This transformation should take place by putting relevant information at the heart of investment, business and policy decisions (CDP 2014).

The CDP's Cities Information Request provides information about climate change related risks, opportunities and adaptation actions for cities. The results help to improve the understanding of sources of urban GHG emissions and they should provide a framework for developing GHG inventories and ensure that emissions are reported meaningfully. Furthermore, with the aid of the reported results potential risks as well as opportunities that arise from climate change can be highlighted. In this way, the understanding of how local governments or other stakeholders deal with climate change can also be enhanced. However, the fact that all answers are based on subjective self-assessment needs to be taken into consideration when evaluating the responses (CDP 2014).

In this paper, responses to the 2014 CDP Information Request have been put together and analyzed for all European cities which submitted a report. The paper is structured as follows. The second chapter provides a general introduction to the topic of cities and climate change with a special focus on issues in European cities. Chapter three explains the methodology and the data basis used in this paper. The fourth chapter deals with physical risks that cities have to deal with on a local level. Chapter five gives an elaboration on social risks for cities that local governments may encounter as a result of climate change. The sixth chapter deals with the economic opportunities that arise from climate change impacts before depicting adaptation plans and options in chapter seven. Chapter eight concludes.

2. European cities and climate change

European cities are important economic hubs, but also centers of innovation, population and employment. Overcrowding, competition for services or ageing infrastructure pose problems to several cities which can result in social problems like unemployment in neighborhoods but also environmental problems like air pollution caused by industry or transportation. Those challenges will increase in the future as cities are constantly growing. According to the European Environment Agency (EEA 2012), about 80% of the European population will live in cities by 2020. Additionally, cities will also experience demographic changes (e.g. ageing population) which will cause higher vulnerabilities regarding the quality of life in cities, health, biodiversity as well as economic competitiveness. Climate change causes additional challenges with impacts like floods, heatwaves, or water scarcity. Furthermore, not only

environmental threats are intensified but also socio-economic challenges. At the same time, climate change can also open up opportunities (Perks 2013).

Climate change-related risks and its widespread impacts on people, economies and ecosystems are increasing steadily, as also the IPCC (2014) points out. For Europe climate projections show a marked increase in high temperature extremes, meteorological droughts, heavy precipitation events with variations across Europe and small or no changes in wind speed extremes except increases in winter wind speed extremes over Central and Northern Europe. Climate change will increase the likelihood of systemic failures across European countries caused by extreme climate events affecting multiple sectors. Extreme weather events currently have significant impacts in Europe in multiple economic sectors as well as adverse social and health effects. There is limited evidence that resilience to heat waves and fires has improved in Europe. Furthermore the general capacity to adapt in Europe is high compared to other world regions, but there are important differences in impacts and in the capacity to respond between and within the European sub-regions (IPCC 2014).

An important aspect with regard to adaptation is that Europe's resilience depends on local action as cities can develop locally appropriate measures for responding to impacts of climate change. They have the highest knowledge of local conditions, can develop strategies and also build networks (Perks 2013).

Much of key and emerging global climate risks are concentrated in urban areas (IPCC 2014) and in this way, many of these risks and impacts will hit urban areas in particular, regardless of their size, location or economic and social circumstances, as currently about half of the world's population lives in cities and this share will increase to 60% in 2030 (OECD 2010). Cities are centers of economic activity where most of society's built assets are located, generating about 80% of global GDP. Thus, the density of people and assets increases the concentration of risk from climate change and makes cities particularly vulnerable but at the same time especially worthy to protect (IPCC 2014). However, the degree of vulnerability depends on the city's specifics e.g. geographical location, adaptive capacity regarding financial and human resources, management strategies and factors like fresh air zones (Tanner et al. 2009).

Generally, cities are exposed to climate change in the same way as their surroundings, but impacts are altered by urban conditions. Within cities a unique microclimate is created as the natural vegetation is replaced by artificial surfaces. Consequently, i.a. precipitation patterns, air temperature or wind direction are altered. Due to climate change, some of these elements are exacerbated while others are lessened (EEA 2012; IPCC 2014). Air quality, waste

management, land use, water availability as well as water quality have implications for urbanization (UNISDR 2012). These implications might be aggravated by systemic interactions, e.g. the built environment reflects less sunlight but absorbs more heat than vegetation. In addition, the concentration of energy usage causes the concentration of waste heat which is why cities are warmer than the surrounding and exacerbate higher temperatures caused by global warming (OECD 2010).

Additionally, climate change will have impacts on infrastructure systems, services, the built environment as well as ecosystem services which all interact with other social, economic, and environmental factors exacerbating risks to individual and household well-being (IPCC 2014). Moreover, cities are affected by events outside urban areas, e.g. flooding because of inappropriate flood management or land use in regions upstream. Consequently, cities in water scare regions compete for water with agriculture or other sectors (EEA 2012). Furthermore, those implications can also have economic impacts like interruption of transport systems, reduced productivity, loss of workdays or efficiency losses in the transmission and generation of energy (Tanner et al. 2009).

In general, the following four major aspects of climate change are relevant to cities, which have also been considered in the CDP Cities Information Request on physical risks:

I. Heat: Large amounts of concrete and asphalt as well as heat from cooling equipment exacerbate urban heat island effects (IPCC 2007; IPCC 2014) causing an increased air temperature (up to additional 10°C) in urban areas compared to rural surroundings. Heat waves will thus be more intense in cities. Generally, the number of hot days has increased for urban as well as for rural areas, but the number of hot nights is higher in cities as within urban areas, as more heat is stored during the day and released during the night. Especially higher temperatures during nighttime are causing negative effects for people's health because the relief of cool nights is missing. During the last decades, heatwaves have caused more fatalities than any other natural disaster. For example, during the heatwave in 2003 in Central and Western Europe about 70,000 people died within a period of four months. This demonstrates that not only Southern European cities are affected (EEA 2012).

II. Floods: According to available monitoring data, events of heavy rainfall will increase in frequency in most areas but significantly in urbanized regions (IPCC 2007; IPCC 2014). Climate change increases the likelihood of high river flows in huge parts of Europe, especially in Western and Central Eastern Europe. Urban drainage flooding takes place in Western and Northern Europe and coastal floods can be particularly observed along North-Western European, Northern Italian and Romanian coasts. Even in regions that are predicted to

become dryer on average, floods might occur more frequently. For example, there have been 12 floods between 1950 and 2006 in Europe causing the greatest economic losses due to natural hazards (EEA 2012).

III. Droughts: Areas affected by drought will increase and perceive negative impacts on food production, energy and water supply as well as health (IPCC 2007; IPCC 2014). Determining factors are intertwined with socio-economic changes – e.g. population growth, urbanization, increase of consumption and land use are causing competing demand for publicly available water and water for sectors like agriculture and industry. Due to an imbalance between demand for and availability of water, resources are predicted to diminish in Europe. Some cities in Southern and Eastern Europe already suffer from water stress during summer and projections show an aggravation as well as an extension of this problem (EEA 2012).

IV. Storms: Projections for Europe show a decrease in the total number of storms, but at the same time an increase in the storms' strength. However, in the Atlantic region storms will be stronger but also more frequent. There will be a significant increase in storms at the North Sea and the South-east of England. Storms in general are the biggest climate change related threat for built-up areas, especially for roofs and facades (IPCC 2014). Furthermore, fallen lampposts or trees might also jeopardize transport and supply systems affecting many fields of life. Until 2080, insured losses caused by extreme wind will increase by 5% even if only considering climate change factors. Nevertheless, storm events are uncertain and difficult to predict, also because storms often occur in combination with other extreme weather events like hail, heavy precipitation or thunder (EEA 2012).

Between 775,000 and 5.5 million people will be affected annually by climate change related damage until 2080 without adaptation. However, the number of people affected can be reduced drastically through adaptation measures. At the same time, adaptation can be an opportunity for the creation of jobs, the promotion of innovation and also for the implementation of profound changes (EEA 2012). Thus, adaptation to impacts caused by climate change does not only help to reduce risk for municipalities, but also provides opportunities for businesses to thrive (CDP 2014). Even though mitigation and adaptation require huge investments, delaying actions might even increase future costs and limit further options for adaptation or the reduction of emissions. Especially direct costs caused by extreme weather events or related to sea level rise can be extremely high. However, spatial planning as well as land management has to be initiated long before the adaption option will be effective. Current efforts of adaptation are challenged by uncertainty about impacts of climate change as the benefits of adaptation can only be observed in the future (OECD 2010).

3. Methodology and data basis

The cities' risks, opportunities and adaptation actions analyzed in this paper are based on the cities' responses to the 2014 CDP Cities Information Request[4] as part of the CDP Cities Program. The CDP Cities Information Request is composed of a series of sections that capture details on the different cities, including GHG emissions, information on risks and opportunities that arise from climate change as well as strategies for mitigating emissions and for adapting to climate change. In this paper, the individual responses for each city are analyzed and presented, focusing only on two modules within the CDP Cities Information Request, namely the module "risks & adaptation" and the module "opportunities".

Within the paper, the following 40 European cities – ranging from Moscow (with a population of about 11.97 million) to the tiny village of Kadiovacik in Turkey (consisting of only 216 people) – are analyzed:

> Amsterdam*, Athens*, Berlin*, Bologna, Bornova, Cascais, Copenhagen*, Dublin, Fafe, Faro, Ferrara, Genoa, Glasgow, Hamburg, Kadiovacik, Lisbon, London*, Madrid*, Manchester, Milan* (2011), Moscow*, Naples, Oristano, Oslo*, Padua, Paris*, Piacenza, Porto, Rome* (2012), Rotterdam* (2013), Seixal, Stockholm*, Turin, Turku, Venice*, Vila Nova De Gaia, Vilnius (2013), Warsaw*, Zaragoza, Zurich.

Except for the cities indicated by another reporting year in brackets[5], the answers taken into account are based on the cities' responses to the 2014 CDP Cities Information Request. Thereby the cities highlighted with a '*' are part of the C40 Cities Climate Leadership Group[6], a network of the world's megacities committed to addressing climate change.

Referring to the number of inhabitants, the cities can be grouped into i) small cities, ii) medium-sized cities and iii) large cities (CDP 2012):[7]

- Small cities (< 600,000 inhabitants):

  Kadiovacik[8] (216), Oristano[9] (32,015), Fafe[10] (49,579), Faro (63,172), Piacenza (100,843), Ferrara (131,842), Turku (178,630), Seixal (160,237), Padua (207,245),

[4] All data from CDP is available free of charge for research (non-commercial purposes). In order to view individual public cities responses one needs to register to the CDP ("My CDP") at https://www.cdp.net/en-US/MyCDP/Anonymous/Login.aspx.

[5] These cities did not respond in 2014. Therefore the most current year of reporting was taken into account.

[6] http://www.c40.org/.

[7] Population data was retrieved from Eurostat 2012, exceptions are indicated.

[8] Figure indicated by the city itself in its response file.

[9] ISTAT.it, as of 2010, http://sitis.istat.it/sitis/html/indexEng.htm (accessed 10.09.2015).

Cascais[11] (209,376), Porto (233,061), Venice (259,263), Vila Nova de Gaia (303,430), Zurich (376,990), Bologna (380,635), Bornova[12] (399,023), Manchester (503,127), Dublin (516,255), Vilnius (533,279), Lisbon (537,412), Copenhagen (559,440), Genoa (582,320), Rotterdam (587,134), Glasgow (594,100).

- Medium-sized cities (600,000-1.6 million inhabitants):
  Oslo (613,285), Athens (799,979), Zaragoza (679,624), Amsterdam (755,605), Stockholm (864,324), Turin (872,091), Naples (959,052), Milan (1.26 million).
- Large cities (> 1.6 million inhabitants):
  Warsaw (1.72 million), Hamburg (1.80 million), Paris (2.25 million), Rome (2.64 million), Madrid (3.23 million), Berlin (3.50 million), London[13] (8.17 million), Moscow[14] (11.97 million).

Thus, 60% of all reporting European cities can be classified as small cities, 20% as medium-sized and another 20% as large cities, respectively.

The analysis includes cities from 18 different countries:

- Denmark: Copenhagen
- Finland: Turku
- France: Paris
- Germany: Berlin, Hamburg
- Greece: Athens
- Great Britain: Glasgow, London, Manchester
- Ireland: Dublin
- Italy: Bologna, Ferrara, Genoa, Milan, Naples, Oristano, Padua, Piacenza, Rome, Turin, Venice
- Lithuania: Vilnius
- Netherlands: Amsterdam, Rotterdam
- Norway: Oslo
- Poland: Warsaw

[10] Statistics Portugal, as of 2014, https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&contecto=pi&indOcorrCod=0008273&selTab=tab0 (accessed 10.09.2015).
[11] Statistics Portugal, as of 2014, https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&contecto=pi&indOcorrCod=0008273&selTab=tab0 (accessed 10.09.2015).
[12] Turkish Statistical Institute (2008): Regional Indicators TR31 İzmir. Ankara, Turkish Statistical Institute.
[13] London (greater city).
[14] Statista, as of 2014, http://de.statista.com/statistik/daten/studie/200633/umfrage/groesste-staedte-in-russland/ (accessed 10.09.2015).

- Portugal: Cascais, Fafe, Faro, Lisbon, Porto, Seixal, Vila Nova de Gaia
- Russia: Moscow
- Spain: Madrid, Zaragoza
- Sweden: Stockholm
- Switzerland: Zurich
- Turkey: Bornova, Kadiovacik

The timeline for responses to the 2014 CDP Cities Information Request was as follows (CDP 2014). In August 2013 the CDP started consultations on the information request, and in November 2013 a letter of invitation was sent to the leaders of each of the cities already in the sample of formerly participating cities. An electronic version of the information request was also published on the CDP website. In this way, cities not yet participating were able to join the program by expressing their interest via email. Starting in January 2014, the CDP Cities Online Response System became operational for responding cities. Deadline for the cities' responses was the 28th of March 2014. The responses were analyzed by the CDP until the end of June 2014 and the results were subsequently launched in July 2014.

Before responding via the CDP Online Response System, cities have the option to choose whether the answers should be available to the public or whether they should be kept in confidence, meaning that the answers are only accessible by the CDP. Within this paper only publicly available answers were analyzed.

4. Physical risks

Even though climate change takes place on a global scale, its effects will have local consequences for cities. Therefore, this chapter gives an overview of the reported current and/or anticipated physical risks cities face due to climate change. These risks may arise from dramatic extreme weather events or subtle changes in weather patterns. Moreover, their impact may be direct or indirect, i.e. affecting other infrastructures upon which the city relies. The CDP uses the IPCC definition of risk as the probability of a hazardous event or trend, multiplied by the consequences of this event. The consequences of a hazardous event are referred to as impacts (CDP 2015).

Responses regarding physical risk factors are reported to the CDP by using a drop down menu, including:

- More hot days
- Hotter summers
- More frequent heatwaves

- More intense heatwaves
- Warmer water temperatures
- Increased urban heat island effect
- More frequent rainfall
- More intense rainfall
- Increased average annual rainfall
- Reduced average annual rainfall
- Reduced average annual snowfall
- More frequent droughts
- More intense droughts
- Change in seasonality of rainfall
- Increased risk of storm surges
- Increased frequency of large storms
- Increased wind speeds
- Sea level rise
- Other

Furthermore, the cities have been asked to list and describe the effects of climate change together with the related impacts, magnitudes and anticipated timescales. However, due to the contextual nature of climate change impacts, the CDP does not provide a standard definition for what constitutes an extremely serious, serious or less serious impact. Cities are asked to report the magnitude and the anticipated timescale, preferably based on the outcome of a risk or vulnerability assessment process (CDP 2014).

Within the CDP Cities Information Request, the level of risk can be rated by cities as follows (CDP 2014):

- „Extremely serious: If you anticipate that the expected effect of climate change poses the highest level of potential concern to your city. For example, you might choose this option if your city expects large storms to have a significant impact on your city within a short time period."
- „Serious: If you anticipate that the expected effect of climate change poses a significant level of concern to your city. For example, you might choose this option if your city expects large storms to have a significant impact on your city within a medium time frame."
- „Less serious: If you anticipate that the expected effect of climate change will have a lower impact within a longer timescale."

Regarding the anticipated timescale in years, the CDP Cities Information Request provides the following four options (CDP 2014):

- „Current: If your city is already experiencing the identified impact from climate change."
- „Short-term: If you anticipate your city will experience the identified impact from climate change by 2025."
- „Medium-term: If you anticipate your city will experience the identified impact from climate change between 2026 and 2050."
- „Long-term: If you anticipate your city will experience the identified impact from climate change after 2051."

In general, almost all cities (92.5%) report that they face physical risks arising from climate change. Only two small cities (Bornova, Fafe) indicate that they do not know whether they face such risks, but list some of them anyways. Naples as a medium-sized city is the only one not to give an answer to this question.

The top-five reported physical risk for cities are i) *more intense rainfall* (62.5% of all cities report to be facing this risk), ii) *more frequent heat waves* (37.5%), iii) *more hot days* (35%), iv) *hotter summers* (32.5%) as well as v) *an increased urban heat island effect* (32.5%). The cities had the opportunity to name additional risks that they are facing, categorized as other physical risks. Those mentioned include for example *increase of allergenic pollens* or *landslides*.[15]

Most cities judge the level of physical risks to be serious and the more cities indicate that they are aware of a certain risk, the more pressing this risk is assessed on the anticipated timescale (for more detailed results see appendix, tables 1 to 21).[16]

[15] *Floods* as well as *increased annual average temperature* were indicated by several cities, which is why these risks were evaluated separately.

[16] The results regarding the risks which are presented in the appendix are structured as follows. All risks reported by the cities are listed, starting with the most common risks. Within the evaluation, the proportion of all participating European cities which reported to face a particular risk was calculated, as well as the proportion of cities which rated the specific risk to be extremely serious, serious or less serious, and, with regards to the anticipated timescale, current, short-term, medium-term or long-term, respectively. Percentages were rounded to two decimal places.

5. Social risks

Besides physical risks, there are also highly relevant social risks for cities that local governments may encounter as a result of climate change. Social risks are based on cities' specific demographics, socio-economic factors or institutional frameworks and they are expected to influence health and wellbeing, social unrest, migration, or the general quality of life within a city (IPCC 2007; CDP 2014).

Hence the cities were also asked to state whether they were facing social risks and which kind, as well as the anticipated timescale by which they expect to experience social risks arising from climate change.

Responses regarding social risk factors are, as well as the physical risks, reported to the CDP by using a drop down menu, including:

- Fluctuating socio-economic conditions
- Increased incidence and prevalence of disease
- Increased demand for public services (including health)
- Increased risk to already vulnerable populations
- Increased conflict and/or crime
- Increased resource demand
- Loss of traditional jobs
- Migration from rural areas to cities
- Population displacement
- Other

Regarding the timescale, the CDP Information Request offers the four options current, short-term, medium-term and long-term, as explained above.

In general, slightly more than half of the reporting cities (55%) indicate that they are facing social risks arising from climate change. However, 25% state that they do not face such risks and 12.5% do not know if they do. Three cities did not answer the question.

Almost half of all small cities (45.83%) are facing social risks and 29.17% declare not to be facing any social risks. 20.83% of these cities answered that they do not know whether they are affected or not and one city did not give an answer. Looking at the medium-sized cities, the results show that 75% are facing social risks. 12.5% of them do not face social risks and one medium-sized city did not answer the question. 62.5% of the large cities are facing social risks, 25% do not and one large city did not give an answer (see appendix, table 22).

The most relevant social risk identified by cities are i) an *increased risk to already vulnerable populations* (35%), ii) an *increased incidence and prevalence of disease* (25%), iii) an

increased demand for public services, including health (22.5%), and iv) *fluctuating socio-economic conditions* (15%). Also in this category, the cities had the opportunity to name additional (other) social risks that they are facing. Those indicated include *destruction of buildings and structure*, *increased risks to the urban infrastructure (power supply, transportation)* and *resettlement of people living in coastal areas of high susceptibility to flood.* Looking at the anticipated timescale, no strong tendency can be observed (see appendix, tables 23 to 31).

6. Economic opportunities

Since climate change does not only go along with risks but may also open up economic opportunities, this chapter presents the economic opportunities which arise from mitigating and adapting to climate change as identified by the reporting cities. As pointed out in the CDP guidance document (CDP 2014), economic opportunities like the development of new goods and services may primarily come up for cities and regions with a strong foundation in scientific and technological research and development, advanced manufacturing, export facilities, or those well-endowed with renewable energy resources.

Within the CDP Information Request, cities were asked to indicate possible opportunities and to describe how they anticipate taking advantage of them. A drop down list of the following possible economic opportunities was provided, out of which all relevant options could be selected:

- Development of new business industries (e.g. clean tech)
- Additional funding opportunities
- Improved efficiency of operations
- Increased energy security
- Increased attention to other environmental concerns
- Increased infrastructure investment
- Other

Regarding economic opportunities, the cities' responses show that 72.5% of the cities actually indicate economic opportunities. 10% of the responding cities do not see any opportunities and another 12.5 % do not know. Two cities did not answer the question.

In matters of the cities' different sizes, the results show that two thirds of small cities state that climate change presents economic opportunities. 12.5% of them do not see any opportunities and 16.67% do not know. One small city did not reply. With a share of 87.5% almost all medium-sized cities see opportunities, while only one of them did not answer the

question. Also most of the large cities (75%) have already identified opportunities, whereas in each case one city does not see opportunities or does not know if it does (see appendix, table 32).

More than half of the reporting cities (57.5%) identify *development of new business industries* as the main economic opportunity arising from climate change. Almost a quarter of the cities (22.5% respectively) perceive *improved efficiency of operations* as well as *increased attention to other environmental concerns* as good opportunities (see appendix, table 33).

7. Adaptation plans and actions

As pointed out above, European cities are already facing and considering climate change related risks and economic opportunities. In the face of these developments, many cities are responding by developing adaptation plans. Adaptation planning covers how the city will change to meet the new challenges posed by climate change as well as policy changes (CDP 2012). According to the CDP guidance document for cities, a climate adaptation plan can be defined as a "planned response across the city's services and departments in order to address and manage future climate change risks" (CDP 2014, p. 18). By using a climate adaptation plan, climate change risks can be addressed in a preventive manner through the implementation of concrete measures. Furthermore, cities can be enabled to proactively focus on opportunities arising from a changing climate and take them into account at an early stage. To get a closer look on adaptation plans and actions cities have already implemented, they were first asked to indicate whether they have already developed an adaptation plan (or resilience plan, respectively).

In 2014, more than half of the observed European cities (55%) indicated that they have already implemented an adaptation action plan, while 40% have not yet developed adaptation plans. Two cities did not answer the question.

Regarding the cities' size, the results show that one half of the small cities has already developed an adaptation plan and the other half did not. Also 50% of the medium-sized cities have already implemented an adaptation plan. However, 37.5% did not yet implement one and one city did not answer the question. Large cities are frontrunners when it comes to developing adaptation plans – 75% of them already did so, one city did not and one large city did not reply (see appendix, table 34).

Beyond adaptation plans, it is interesting to have a further look on the adaptation actions that cities are undertaking in order to adapt to climate change. Within the CDP Information Request, cities could choose different actions to reduce vulnerability from a list (such as

community engagement/education or *tree planting and/or creation of green space*) to match the various effects (physical risks) of climate change they had indicated before.

The results show that 82.5% of all cities are already putting adaptation action into practice, while only 17.5% do not take any actions or do not provide sufficient answers. The answers of the reporting cities show that 83.33% of all small cities, 75% of all medium-sized cities and even 87.5% of all large cities are undertaking actions (see appendix, table 35).

The adaptation action that was indicated the most by participating cities was *tree planting and/or creation of green space,* followed by *resilience and resistance measures for buildings, crisis management including warning and evacuation systems, flood defenses-development and operation & storage, storm water capture systems* and *community engagement/education* (see appendix, table 36).

There exist multiple possible actions to adapt to a certain effect of climate change. Most adaptation actions deal with i) *more intense rainfalls* (50% of cities have taken action responding to this effect), ii) *an increased urban heat island effect* (27.5%), iii) *hotter summers* (25%) and iv) *more hot days* (25%) (see appendix, tables 37 to 54).

8. Conclusion

Europe is already – and will be in the future – affected by impacts related to climate change. Thus, adaptation action is important for preventing further damage and, together with mitigation, is a powerful, resource-efficient means to address climate change (IPCC 2014). Urban governments play a key role in urban climate adaptation, as a lot of adaptation depends on local assessments and integrating adaptation into local investments, policies, and regulatory frameworks. Important factors to successful urban adaptation are: building human and institutional capacity; coordinated support from higher levels of governments, the private sector, and civil society; horizontal learning through networks of cities and practitioners. Moreover, a scientific evidence base in each urban center which provides local risk and vulnerability assessments, information and data is essential (IPCC 2014).

The paper provides additional insights into climate change related risks, opportunities and adaptation actions related to cities by analyzing 40 European cities responses to the 2014 CDP Cities Information Request.

The analysis shows that 92.5% of the responding European cities report that they face physical risks arising from climate change. According to the assessment of the participating cities, the top-five reported physical risk for cities are i) *more intense rainfall* (62.5%), ii)

more frequent heat waves (37.5%), iii) *more hot days* (35%), iv) *hotter summers* (32.5%) as well as v) *an increased urban heat island effect* (32.5%).

Moreover, more than half of the cities (55%) indicate that they are facing social risks due to climate change, while medium-sized cities feel especially affected (75% say that they are facing such risks). The most relevant social risk identified by cities are i) a*n increased risk to already vulnerable populations* (35%), ii) *an increased incidence and prevalence of disease* (25%), iii) *an increased demand for public services, including health* (22.5%) and iv) *fluctuating socio-economic conditions* (15%).

However, 72.5% of the cities report that they see economic opportunities in climate change. It should be pointed out that almost all medium-sized cities (87.5%) anticipate economic opportunities, while in this case large cities (75%) and small cities (66%) seem to be slightly less optimistic. More than half of the reporting cities (57.5%) identify *development of new business industries* as the main economic opportunity arising from climate change.

In the face of the risks which arise from climate change, 55% of the observed European cities indicate that they have already implemented an adaptation action plan, with large cities being frontrunners in this area (75%). Additionally, 82.5% of all cities are already putting adaptation action into practice and most adaptation actions deal with i) *more intense rainfalls* (50%), ii) *an increased urban heat island effect* (27.5%), iii) *hotter summers* (25%) and iv) *more hot days* (25%). These areas overlap greatly with the top-five reported physical risk for cities. The particular adaptation actions which were indicated the most by participating cities were *tree planting and/or creation of green space,* followed by *resilience and resistance measures for buildings* and *crisis management including warning and evacuation systems.* These also match with the physical risks identified, as these adaptation actions can be interpreted as answers to a more intense rainfall as well as an increase in temperature.

It seems that in general the European cities analyzed within this paper demonstrate knowledge, awareness and on-the-ground experience when it comes to climate change, its corresponding risks and opportunities as well as managing those risks and taking advantage of opportunities at a local level. However, more European cities will need to continue innovating and striving for excellence in this field.

All in all, the CDP Information Request can be an important tool to gain insights into cities' assessment of physical and social risks and economic opportunities related to climate change, as well as adaptation actions and plans. However, the answers are based on subjective self-assessment and are additionally biased by drop down menus. Moreover, the study is solely based on already active cities and cities that participate voluntarily.

Nevertheless, the CDP Cities Information Request confronts cities with the topic of climate change adaptation and can help cities to identify climate change related issues and might trigger adaptation actions. Furthermore, the variety of answers shows that there is no "one-size fits all solution" when it comes to adapting cities to climate change. Thus, the study's findings can also serve as an innovative starting point for further research as well as the practical implementation of adaptation measures.

References

Bender, S., Cortekar, J. and Groth, M. (2015): Adaptation strategies: Looking for best practices only can lead to deadlock. In: Book of Abstracts "European Climate Change Adaptation Conference (ECCA) 2015". Copenhagen. Denmark: 72-73.

Bender, S., Cortekar, J and Groth, M. (2014): Supporting cities to adapt to climate change by using a modular toolkit – first results and lessons learnt. In: Book of Abstracts "3rd Nordic International Conference on Climate Change Adaptation 2014". Copenhagen. Denmark: 155.

CDP (2015): CDP Cities 2015 Guidance for responding city governments. Available from: https://www.cdp.net/Documents/Guidance/2015/CDP-cities-guidance-2015.pdf [Access Date: 05.10.2015].

CDP (2014): CDP Cities 2014 Guidance for responding city governments. Available from: https://www.cdp.net/Documents/Guidance/2014/CDP-cities-guidance-2014.pdf [Access Date: 05.10.2015].

CDP (2012): Seven Climate Change Lessons from the Cities of Europe. CDP Cities 2012. Available from: https://www.cdp.net/CDPResults/CDP-Cities-2012-European-Report.pdf [Access Date: 05.10.2015].

Cortekar, J., Bender, S. and Groth, M. (2015): How to adapt to climate change - challenges for cities. In: Book of Abstracts "European Climate Change Adaptation Conference (ECCA) 2015", Copenhagen, Denmark: 43.

EEA (2012): Urban adaptation to climate change in Europe – Challenges and opportunities for cities together with supportive national and European policies. EEA Report No 2, 2012. Copenhagen: European Environmental Agency.

IPCC (2014): Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York. Cambridge University Press.

IPCC (2007): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge. Cambridge University Press.

OECD (2010): Cities and Climate Change. Paris: OECD Publishing.

Perks, J. (2013): Adaptation Strategies for European Cities. Final Report for EC Directorate General for Climate Action. Ricard-AEA/R/ED57248. Oxfordshire.

Tanner, T., Mitchell, T., Polack, E. and Guentheret, B. (2009): Urban Governance for Adaptation: Assessing Climate Change Resilience in Ten Asian Cites. IDS Working Paper 315. Institute of Development Studies. University of Sussex. Sussex.

UNISDR (2012): Making Cities Resilient Report 2012 – My city is getting ready! A global snapshot of how local governments reduce disaster risk. Geneva.

Appendix

Physical Risks

Table 1: Physical risks – More intense rainfall

City	Level of risk	Anticipated timescale
Amsterdam	Serious	Medium-term
Athens	Serious	Current
Berlin	Serious	Medium-term
Bornova	Serious	Short-term
Copenhagen	Serious	Short-term
Ferrara	Serious	Current
Genoa	Serious	Current
Glasgow	Serious	Current
Hamburg	Serious	Current
Lisbon	Less serious	Medium-term
London	Extremely serious	Short-term
Manchester	Serious	Short-term
Moscow	Less serious	Medium-term
Oristano	Serious	Medium-term
Oslo	Serious	Medium-term
Padua	Serious	Current
Paris	Less serious	Long-term
Rome	Serious	Current
Rotterdam	Serious	Current
Stockholm	Serious	Short-term
Turin	Serious	Medium-term
Turku	Serious	Current
Venice	Extremely serious	Current
Vilnius	Less serious	Long-term
Warsaw	Serious	Current
25/40 (62.50%)	**Extremely serious: 2/25 (8.00%)** **Serious: 19/25 (76.00%)** **Less serious: 4/25 (16.00%)**	**Current: 11/25 (44.00%)** **Short-term: 5/25 (20.00%)** **Medium-term: 7/25 (28.00%)** **Long-term: 2/25 (8.00%)**

Table 2: Physical risks – More frequent heat waves

City	Level of risk	Anticipated timescale
Athens	Extremely serious	Current
Berlin	Serious	Medium-term
Cascais	Extremely serious	Medium-term
Fafe	Serious	Short-term
London	Extremely serious	Medium-term
Moscow	Less serious	Medium-term
Padua	Serious	Current
Paris	Extremely serious	Current
Porto	Less serious	Short-term
Rome	Serious	Short-term
Rotterdam	Less serious	Medium-term
Stockholm	Less serious	Medium-term
Turin	Serious	Medium-term
Venice	Serious	Current
Zurich	Serious	Long-term
15/40 (37.50%)	**Extremely serious: 4/15 (26.67%)** **Serious: 7/15 (46.67%)** **Less serious: 4/15 (26.67%)**	**Current: 4/15 (26.67%)** **Short-term: 3/15 (20.00%)** **Medium-term: 7/15 (46.67%)** **Long-term: 1/15 (6.67%)**

Table 3: Physical risks – More hot days

City	Level of risk	Anticipated timescale
Athens	Extremely serious	Current
Bornova	Serious	Current
Cascais	Extremely serious	Medium-term
Hamburg	Serious	Medium-term
Kadiovacik	Less serious	Long-term
Lisbon	Less serious	Current
Manchester	Less serious	Short-term
Moscow	Less serious	Medium-term
Padua	Serious	Current
Paris	Serious	Short-term
Rome	Serious	Short-term
Turin	Serious	Medium-term
Venice	Serious	Current
Vilnius	Serious	Long-term
14/40 (35.00%)	**Extremely serious: 2/14 (14.29%)** **Serious: 8/14 (57.14%)** **Less serious: 4/14 (28.57%)**	**Current: 5/14 (35.71%)** **Short-term: 3/14 (21.43%)** **Medium-term: 4/14 (28.57%)** **Long-term: 2/14 (14.29%)**

Table 4: Physical risks – Hotter summers

City	Level of risk	Anticipated timescale
Athens	Extremely serious	Short-term
Berlin	Serious	Medium-term
Bologna	Serious	Current
Bornova	Serious	Current
Faro	Less serious	Current
London	Extremely serious	Medium-term
Moscow	Less serious	Long-term
Padua	Serious	Current
Paris	Extremely serious	Short-term
Rome	Serious	Current
Turin	Serious	Medium-term
Venice	Serious	Current
Zaragoza	Serious	Short-term
13/40 (32.50%)	**Extremely serious: 3/13 (23.08%)** **Serious: 8/13 (61.54%)** **Less serious: 2/13 (15.38%)**	**Current: 6/13 (46.15%)** **Short-term: 3/13 (23.08%)** **Medium-term: 3/13 (23.08%)** **Long-term: 1/13 (7.69%)**

Table 5: Physical risks – Increased urban heat island effect

City	Level of risk	Anticipated timescale
Amsterdam	Serious	Medium-term
Athens	Extremely serious	Current
Bologna	Serious	Current
Lisbon	Less serious	Current
London	Less serious	Medium-term
Manchester	Serious	Long-term
Moscow	Less serious	Medium-term
Padua	Serious	Current
Paris	Extremely serious	Current
Porto	Less serious	Current
Rome	Serious	Short-term
Rotterdam	Less serious	Medium-term
Vilnius	Less serious	Long-term
13/40 (32.50%)	**Extremely serious: 2/13 (15.38%)** **Serious: 5/13 (38.46%)** **Less serious: 6/13 (46.15%)**	**Current: 6/13 (46.15%)** **Short-term: 1/13 (7.69%)** **Medium-term: 4/13 (30.77%)** **Long-term: 2/13 (15.38%)**

Table 6: Physical risks – Sea level rise

City	Level of risk	Anticipated timescale
Cascais	Serious	Medium-term
Copenhagen	Serious	Medium-term
Faro	Serious	Long-term
London	Less serious	Long-term
Rome	Less serious	Long-term
Rotterdam	Serious	River zones: medium-term Inland urban area: long-term
Stockholm	Extremely serious	Long-term
Seixal	Serious	Medium-term
Venice	Extremely serious	Current
Vila Nova de Gaia	Less serious	Current
10/40 (25.00%)	**Extremely serious: 2/10 (20.00%)** **Serious: 5/10 (50.00%)** **Less serious: 3/10 (30.00%)**	**Current: 2/10 (20.00%)** **Medium-term: 3/10 (30.00%) bzw. 4/10 (40.00%)** **Long-term: 4/10 (40.00%) bzw. 5/10 (50.00%)**

Table 7: Physical risks – Change in seasonality of rainfall

City	Level of risk	Anticipated timescale
Berlin	-	-
Hamburg	Serious	Medium-term
Lisbon	Less serious	Current
London	Extremely serious	Medium-term
Moscow	Less serious	Medium-term
Paris	Less serious	Medium-term
Turin	Serious	Short-term
7/40 (17.50%)	**Extremely serious: 1/7 (14.29%)** **Serious: 2/7 (28.57%)** **Less serious: 3/7 (42.86%)**	**Current: 1/7 (14.29%)** **Short-term: 1/7 (14.29%)** **Medium-term: 4/7 (57.14%)**

Table 8: Physical risks – More frequent droughts

City	Level of risk	Anticipated timescale
Bologna	Serious	Current
Lisbon	Less serious	Current
Moscow	Less serious	Medium-term
Paris	Serious	Medium-term
Rotterdam	Serious	Medium-term
Turin	Serious	Long-term
Zurich	Serious	Long-term
7/40 (17.50%)	**Serious: 5/7 (71.43%)** **Less serious: 2/7 (28.57%)**	**Current: 2/7 (28.57%)** **Medium-term: 3/7 (42.86%)** **Long-term: 2/7 (28.57%)**

Table 9: Physical risks – Increased frequency of large storms

City	Level of risk	Anticipated timescale
Paris	Serious	Other
Rotterdam	Serious	Short-term
Seixal	Serious	Medium-term
Turku	Serious	Current
Vilnius	Serious	Long-term
5/40 (12.50%)	**Serious: 5/5 (100.00%)**	**Current: 1/5 (20.00%)** **Short-term: 1/5 (20.00%)** **Medium-term: 1/5 (20.00%)** **Long-term: 1/5 (20.00%)** **Other: 1/5 (20.00%)**

Table 10: Physical risks – More intense droughts

City	Level of risk	Anticipated timescale
Ferrara	Serious	Current
Moscow	Less serious	Medium-term
Paris	Serious	Long-term
Turin	Serious	Long-term
Zaragoza	Serious	Short-term
5/40 (12.50%)	**Serious: 4/5 (80.00%)** **Less serious: 1/5 (20.00%)**	**Current: 1/5 (20.00%)** **Short-term: 1/5 (20.00%)** **Medium-term: 1/5 (20.00%)** **Long-term: 2/5 (40.00%)**

Table 11: Physical risks – Reduced average annual rainfall

City	Level of risk	Anticipated timescale
Athens	Serious	Short-term
Cascais	Serious	Medium-term
Paris	Serious	Medium-term
Venice	Less serious	Short-term
Zaragoza	Serious	Short-term
5/40 (12.50%)	**Serious: 4/5 (80.00%)** **Less serious: 1/5 (20.00%)**	**Short-term: 3/5 (60.00%)** **Medium-term: 2/5 (40.00%)**

Table 12: Physical risks – More intense heat waves

City	Level of risk	Anticipated timescale
Ferrara	Serious	Current
Padua	Serious	Current
Turin	Serious	Medium-term
Venice	Serious	Current
Zaragoza	Serious	Medium-term
5/40 (12.50%)	**Serious: 5/5 (100.00%)**	**Current: 3/5 (60.00%)** **Medium-term: 2/5 (40.00%)**

Table 13: Physical risks – Warmer water temperatures

City	Level of risk	Anticipated timescale
Faro	Less serious	Current
Moscow	Less serious	Medium-term
Paris	Serious	Medium-term
Rotterdam	Less serious	Medium-term
Stockholm	Less serious	Current
5/40 (12.50%)	**Serious: 1/5 (20.00%)** **Less serious: 4/5 (80.00%)**	**Current: 2/5 (40.00%)** **Medium-term: 3/5 (60.00%)**

Table 14: Physical risks – Floods/Flooding/Occurrence of floods and inundation/Floodwater (others)

City	Level of risk	Anticipated timescale
Ferrara	Extremely serious	Short-term
Paris	Extremely serious	Not clear yet
Porto	Serious	Current
Zurich	Serious	Long-term
4/40 (10.00%)	**Extremely serious: 2/4 (50.00%)** **Serious: 2/4 (50.00%)**	**Current: 1/4 (25.00%)** **Short-term: 1/4 (25.00%)** **Long-term: 1/4 (25.00%)** **Not clear yet: 1/4 (25.00%)**

Table 15: Physical risks – More frequent rainfall

City	Level of risk	Anticipated timescale
Copenhagen	Serious	Short-term
Glasgow	Less serious	Current
Moscow	Less serious	Medium-term
Stockholm	Serious	Short-term
4/40 (10.00%)	**Serious: 2/4 (50.00%)** **Less serious: 2/4 (50.00%)**	**Current: 1/4 (25.00%)** **Short-term: 2/4 (50.00%)** **Medium-term: 1/4 (25.00%)**

Table 16: Physical risks – Increased annual average temperature (others)

City	Level of risk	Anticipated timescale
Berlin	Serious	Long-term
Vilnius	Extremely serious	Long-term
2/40 (5.00%)	**Extremely serious: 1/2 (50.00%)** **Serious: 1/2 (50.00%)**	**Long-term: 2/2 (100.00%)**

Table 17: Physical risks – Increased average annual rainfall

City	Level of risk	Anticipated timescale
Dublin	Serious	Medium-term
Moscow	Less serious	-
2/40 (5.00%)	**Serious: 1/2 (50.00%)** **Less serious: 1/2 (50.00%)**	**Medium-term: 1/2 (50.00%)**

Table 18: Physical risks – Increased risk of storm surges

City	Level of risk	Anticipated timescale
Hamburg	Serious	Current
Moscow	Less serious	Medium-term
2/40 (5.00%)	**Serious: 1/2 (50.00%)** **Less serious: 1/2 (50.00%)**	**Current: 1/2 (50.00%)** **Medium-term: 1/2 (50.00%)**

Table 19: Physical risks – Increased wind speeds

City	Level of risk	Anticipated timescale
Moscow	Less serious	Medium-term
1/40 (2.50%)	**Less serious: 1/1 (100.00%)**	**Medium-term: 1/1 (100.00%)**

Table 20: Physical risks – Reduced average annual snowfall

City	Level of risk	Anticipated timescale
Stockholm	Less serious	Short-term
1/40 (2.50%)	**Less serious: 1/1 (100.00%)**	**Short-term: 1/1 (100.00%)**

Table 21: Physical risks – Other physical risks

Risk	City	Level of risk	Anticipated timescale
Allergenic pollens increase	Turin	Serious	Short-term
Existence, but no description of risks	Piacenza	-	-
Increased intense rainfalls	Zurich	Serious	Long-term
Landslide, mudflow	Zurich	Serious	Long-term
Less freezes	Berlin	-	-
NOx exceedances (greenhouse effect gas)	Porto	Serious	current
Occurrence of inundation and coastal overtopping	Porto	Serious	Current
Susceptibility to cold waves	Porto	Less serious	Medium-term
Warmer winters	Padua	Serious	current

Social Risks

Table 22: Cities facing social risks – Overview

Yes	No	Don´t know	No answer
Bologna	Faro	Bornova	Ostario
Cascais	Kadiovacik	Fafe	
Copenhagen	Lisbon	Genoa	Milan
Dublin	Piacenza	Glasgow	
Ferrara	Porto	Turku	Rome
Manchester	Vila Nova		
Padua	Zurich		
Rotterdam			
Seixal	Oslo		
Venice			
Vilnius	Hamburg		
	Warsaw		
Amsterdam			
Athens			
Naples			
Stockholm			
Turin			
Zaragoza			
Berlin			
London			
Madrid			
Moscow			
Paris			
22/40 (55.00%) **Small 11/24 (45.83%)** **Medium 6/8 (75.00%)** **Large (5/8 (62.50%)**	**10/40 (25.00%)** **Small 7/24 (29.17%)** **Medium 1/8 (12.50%)** **Large 2/8 (25.00%)**	**5/40 (12.50%)** **Small 5/24 (20.83%)**	**3/40 (7.50%)** **Small 1/24 (4.17%)** **Medium 1/8 (12.50%)** **Large 1/8 (12.50%)**

Table 23: Social risks – Increased risk to already vulnerable populations

City	Anticipated timescale
Athens	Current
Berlin	Current
Bologna	-
Bornova	Short-term
Cascais	Medium-term
Ferrara	Current
London	Medium-term
Madrid	Medium-term
Paris	Short-term
Rotterdam	-
Stockholm	-
Turin	Medium-term
Venice	Current
Zaragoza	Short-term
14/40 (35.00 %)	**Current: 4/14 (28.57%)** **Short-term: 3/14 (21.43%)** **Medium-term: 4/14 (28.57%)** **No Answer: 3/14 (21.43%)**

Table 24: Social risks – Increased incidence and prevalence of disease

City	Anticipated timescale
Amsterdam	Medium-term
Cascais	Medium-term
Ferrara	Current
Madrid	Medium-term
Manchester	Medium-term
Moscow	Medium-term
Naples	Long-term
Padua	- (Still has to be studied)
Paris	Medium-term
Vilnius	-
10/40 (25.00%)	**Current: 1/10 (10.00%)** **Medium-term: 6/10 (60.00%)** **Long-term: 1/10 (10.00%)** **No Answer: 2/10 (20.00%)**

Table 25: Social risks – Increased demand for public services (incl. health)

City	Anticipated timescale
Athens	Short-term
Bologna	Current
Cascais	Medium-term
London	Medium-term
Madrid	Medium-term
Padua	Still hast to be studied
Paris	Medium-term
Turin	Short-term
Venice	Current
9/40 (22.50%)	**Current: 2/9 (22.22%)** **Short-term: 2/9 (22.22%)** **Medium-term: 4/9 (44.44%)** **No Answer: 1/9 (11.11%)**

Table 26: Social risks – Fluctuating socio-economic conditions

City	Anticipated timescale
Bologna	Current
Bornova	Short-term
Cascais	Short-term
Copenhagen	Long-term
Turin	Medium-term
Vilnius	-
6/40 (15.00%)	**Current: 1/6 (16.67%)** **Short-term: 2/6 (33.33%)** **Medium-term: 1/6 (16.67%)** **Long-term: 1/6 (16.67%)** **No Answer: 1/6 (16.67%)**

Table 27: Social risks – Increased resource demand

City	Anticipated timescale
Cascais	Medium-term
Manchester	Medium-term
Paris	Short-term
Turin	Medium-term
4/40 (10.00%)	**Short-term: 1/4 (25.00%)** **Medium-term: 3/4 (75.00%)**

Table 28: Social risks – Population displacement

City	Anticipated timescale
Cascais	Medium-term
Dublin	Long-term
Paris	Long-term
Venice	current
4/40 (10.00%)	**Current: 1/4 (25.00%)** **Medium-term: 1/4 (25.00%)** **Long-term: 2/4 (50.00%)**

Table 29: Social risks – Increased conflict and/or crime

City	Anticipated timescale
Bologna	-
1/40 (2.50%)	**No answer: 1/1 (100.00%)**

Table 30: Social risks – Loss of traditional jobs

City	Anticipated timescale
Cascais	Medium-term
1/40 (2.50%)	**No answer: 1/1 (100.00%)**

Table 31: Social risks – Other social risks

Risk	City	Anticipated timescale
Destruction of buildings and structure	Moscow	Long-term
Increased risks to the urban infrastructure (power supply, transportation)	Moscow	Medium-term
Resettlement of people living in coastal areas of high susceptibility to flood	Seixal	-

Economic Opportunities

Table 32: Economic opportunities – Overview

Yes	No	Don´t know	No answer
Cascais	Faro	Bologna	Oristano
Copenhagen	Genoa	Bornova	
Dublin	Porto	Piacenza	Milan
Fafe		Zurich	
Ferrara	Rome		
Glasgow		Moscow	
Kadiovacik			
Lisbon			
Manchester			
Padua			
Rotterdam			
Seixal			
Turku			
Venice			
Vila Nova			
Vilnius			
Zaragoza			
Amsterdam			
Athens			
Naples			
Oslo			
Stockholm			
Turin			
Berlin			
Hamburg			
London			
Madrid			
Paris			
Warsaw			
29/40 (72.50%) **Small 16/24 (66.66%)** **Medium 7/8 (87.50%)** **Large 6/8 (75.00%)**	**4/40 (10.00%)** **Small 3/24 (12.50%)** **-** **Large 1/8 (12.50%)**	**5/40 (12.50%)** **Small 4/24 (16.67%)** **-** **Large 1/8 (12.50%)**	**2/40 (5.00%)** **Small 1/24 (4.17%)** **Medium 1/8 (12.50%)** **-**

Table 33: Economic opportunities – Opportunities cities expect regarding climate change

Opportunity	Cities	Amount
Development of new business industries	Amsterdam, Berlin, Bornova, Cascais, Copenhagen, Dublin, Fafe, Glasgow, Hamburg, London, Madrid, Manchester, Moscow, Naples, Oslo, Paris, Rotterdam, Stockholm, Seixal, Turin, Turku, Venice, Warsaw	23/40 (57.50%)
Improved efficiency of operations	Cascais, Fafe, Lisbon, London, Oslo, Paris, Turin, Turku, Zaragoza	9/40 (22.50%)
Increased attention to other environmental concerns	Athens, Bornova, Cascais, Moscow, Paris, Turin, Turku, Venice, Vila Nova de Gaia	9/40 (22.50%)
Additional funding options	Cascais, Ferrara, Kadiovacik, London, Madrid, Turin, Turku	7/40 (17.50%)
Increased energy security	Bornova, Cascais, Copenhagen, Madrid, Turin, Turku, Venice	7/40 (17.50%)
Increased infrastructure investment	Athens, London, Oslo, Rotterdam, Turin, Venice, Vilnius	7/40 (17.50%)
Green jobs (other)	Copenhagen, Glasgow, Hamburg, Paris	4/40 (10.00%)
Increased green entrepreneurship (other)	Berlin, Paris, Stockholm	3/40 (7.50%)
Tourism (other)	Hamburg, Stockholm	2/40 (5.00%)
Energy audit and certification of facilities in the public utilities (other)	Moscow	1/40 (2.50%)
Reduced need for heating buildings (other)	Stockholm	1/40 (2.50%)
Social opportunities (other)	Stockholm	1/40 (2.50%)

Adaptation plans and actions

Table 34: Adaptation action plans – Overview

Yes	No	No answer
Bologna	Bornova	Milan
Cascais	Faro	
Copenhagen	Ferrara	Rome
Dublin	Lisbon	
Fafe	Manchester	
Genoa	Oristano	
Glasgow	Padua	
Kadiovacik	Piacenza	
Rotterdam	Porto	
Venice	Seixal	
Vila Nova	Turku	
Vilnius	Zurich	
Athens	Amsterdam	
Stockholm	Naples	
Turin	Oslo	
Zaragoza		
	Warsaw	
Berlin		
Hamburg		
London		
Madrid		
Moscow		
Paris		
22/40 (55.00%) **Small 12/24 (50.00%)** **Medium 4/8 (50.00%)** **Large 6/8 (75.00%)**	**16/40 (40.00%)** **Small 12/24 (50.00%)** **Medium 3/8 (37.50%)** **Large 1/8 (12.50%)**	**2/40 (5.00%)** **Medium 1/8 (12.50%)** **Large 1/8 (12.50%)**

Table 35: Adaptation actions – Overview

Yes	**No**
Bologna	Bornova
Cascais	Fafe
Copenhagen	Oristano
Dublin	Piacenza
Faro	
Ferrara	Milan
Genoa	Naples
Glasgow	
Kadiovacik	Rome
Lisbon	
Manchester	
Padua	
Porto	
Rotterdam	
Seixal	
Turku	
Venice	
Vila Nova	
Vilnius	
Zurich	
Amsterdam	
Athens	
Oslo	
Stockholm	
Turin	
Zaragoza	
Berlin	
Hamburg	
London	
Madrid	
Moscow	
Paris	
Warsaw	
33/40 (82.50%) **Small 20/24 (83.33%)** **Medium 6/8 (75.00%)** **Large 7/8 (87.50%)**	**7/40 (17.50%)** **Small 4/24 (16.67%)** **Medium 2/8 (25.00%)** **Large 1/8 (12.50%)**

Table 36: Frequency of indication of particular adaptation actions

Adaptation action	Number of times action was indicated by cities
Tree planting and/or creation of green space	18
Resilience and resistance measures for buildings	8
Crisis management including warning and evacuation systems	7
Flood defenses- development and operation & storage	7
Storm water capture systems	6
Community engagement/education	6
Flood Mapping	5
Heat mapping and thermal imaging	5
Biodiversity monitoring	5
Projects and policies targeted at those most vulnerable	4
Green roofs/walls	4
Sea level rise monitoring	3
Crisis planning and practice exercises	3
Restrict development in at risk areas	3
Retrofit of existing buildings	3
Water butts/rainwater capture	3
Xeriscapes- low water landscaping design	3
Additional reservoirs and wells for water storage	3
Water use restrictions and standards	2
Diversification of water supply	2
Real time risk monitoring	2
Cooling systems for critical infrastructure	2
Diversifying power/energy supply	1
Economic diversification measures	1
Disease prevention measures	1
Cool pavement	1
Maintenance/repair – leaking infrastructure	1

Table 37: Adaptation actions – More intense rainfalls

Cities	Adaptation action
Amsterdam, Berlin	Water butts/rainwater capture
Athens	Xeriscapes – low water landscaping design
Cascais, Oslo	Flood mapping
Copenhagen, Glasgow, Warsaw	Resilience and resistance measures for buildings
Ferrara	Community engagement/education
Genoa	Diversifying power/energy supply
Lisbon, Manchester, Padua	Storm water capture systems
London	Combination of actions
Moscow, Stockholm, Venice	Flood defenses – development and operation & storage
Paris	Restrict development in risk areas
Rotterdam	Additional reservoirs and wells for water storage
Turku	Regional plan together with other municipalities for the natural treatment of runoff waters
20/40 (50.00%)	

Table 38: Adaptation actions – Increased urban heat island effect

Cities	Adaptation action
Amsterdam	Green roof/walls
Athens, Lisbon	Heat mapping and thermal imaging
Bologna	Community engagement/education
London, Paris, Rotterdam, Vilnius	Tree planting and/or creation of green space
Manchester	Resilience and resistance measures for buildings
Moscow	Crisis planning and practice exercises
Padua	Studies and analyses with focus on the heat island problem in urban settlements
11/40 (27.50%)	

Table 39: Adaptation actions – Hotter summers

Cities	Adaptation action
Athens, Berlin, Zaragoza	Tree planting and/or creation of green space
Bologna, Moscow	Crisis management including warning and evacuation systems
Faro	Biodiversity monitoring
London	Planning policies
Padua	Green roofs/walls
Paris	Heat mapping and thermal imaging
Venice	Community engagement/education actions
10/40 (25.00%)	

Table 40: Adaptation actions – More hot days

Cities	Adaptation action
Athens	Green roofs/walls
Cascais	Projects and policies targeted at those most vulnerable
Kadiovacik, Lisbon, Manchester	Tree planting and/or creation of green space
Moscow, Paris	Cooling systems for critical infrastructure
Padua	Retrofit of existing buildings
Venice	Crisis management including warning and evacuation systems
Vilnius	Promoting public transport
10/40 (25.00%)	

Table 41: Adaptation actions – More frequent heat waves

Cities	Adaptation action
Athens	Green roofs/walls
Berlin, London	Projects and policies targeted at those most vulnerable
Cascais	Heat mapping and thermal imaging
Moscow	Energy-saving measures
Padua, Stockholm, Venice	Tree planting and/or creation of green space
Paris	Community engagement/education
9/40 (22.50%)	

Table 42: Adaptation actions – Sea level rise

Cities	Adaptation plan
Cascais, Faro, Stockholm	Sea level rise modelling
Copenhagen, London	Flood defenses – development and operation & storage
Rotterdam	Building resilience and resistance measures
Seixal, Vila Nova de Gaia	Biodiversity monitoring
Venice	MOSE mobile barriers
9/40 (22.50%)	

Table 43: Adaptation actions – Change in seasonality of rainfall

Cities	Adaptation action
Berlin	Other
Lisbon	Tree planting and/or creation of green space
London, Moscow	Retrofit of existing buildings
Paris	Crisis planning and practice exercises
Rotterdam	Storm water capture systems
6/40 (15.00%)	

Table 44: Adaptation actions – Reduced average annual rainfall

Cities	Adaptation action
Athens	Xeriscapes – low water landscaping design
Cascais	Restrict development in risk areas
Madrid, Paris	Diversification of water supply
Venice	Water use restrictions and standards
Zaragoza	Biodiversity monitoring
6/40 (15.00%)	

Table 45: Adaptation actions – More frequent droughts

Cities	Adaptation action
Bologna	Water butts/rainwater capture
Lisbon	Xeriscapes – low water landscaping design
Moscow	Real time risk monitoring
Paris	Plant drought resistant trees
Rotterdam	Building resilience and resistance measures
5/40 (12.50%)	

Table 46: Adaptation actions – More intense heat waves

Cities	Adaptation action
Ferrara, Rotterdam	Tree planting and/or creation of green space
Padua	Projects and policies targeted at those most vulnerable
Venice	Crisis management including warning and evacuation systems
Zaragoza	Heat mapping and thermal imaging
5/40 (12.50%)	

Table 47: Adaptation actions – Warmer water temperatures

Cities	Adaptation action
Faro	Biodiversity monitoring
Moscow	Real time risk monitoring
Paris	Water use restrictions and standards
Rotterdam	Building resilience and resistance measures
Stockholm	Diversification of water supply
5/40 (12.50%)	

Table 48: Adaptation actions – Increased risk of storm surges

Cities	Adaptation action
Hamburg, Moscow	Crisis management including warning and evacuation systems
Madrid	Storm water capture systems
Rotterdam	Flood defenses – development and operation & storage
4/40 (10.00%)	

Table 49: Adaptation actions – More frequent rainfall

Cities	Adaptation action
Copenhagen	Additional reservoirs and wells for water storage
Glasgow	Flood mapping
Moscow	Storm water capture systems
Stockholm	Restrict development in at risk areas
4/40 (10.00%)	

Table 50: Adaptation actions – More intense droughts

Cities	Adaptation action
Ferrara	Additional reservoirs and wells for water storage
Moscow	Crisis management including warning and evacuation systems
Paris	Awareness
Zaragoza	Economic diversification measures
4/40 (10.00%)	

Table 51: Adaptation actions – Increased average annual rainfall

Cities	Adaptation action
Dublin	Flood prevention
Moscow	Maintenance/repair
Vilnius	Renovate rainfall systems
3/40 (7.50%)	

Table 52: Adaptation actions – Increased frequency of large storms

Cities	Adaptation action
Paris	Resilience and resistance measures for buildings
Rotterdam	Flood defenses – development and operation & storage / Activate calamity plans
Seixal	Biodiversity monitoring
3/40 (7.50%)	

Table 53: Adaptation actions – Floods/Flooding

Cities	Adaptation action
Ferrara, Paris	Flood mapping
2/40 (5.00%)	

Table 54: Adaptation actions – Other effects of climate change

Risk	City	Adaptation action
Floods and inundation	Porto	Adaptation of sewers facilities for extreme situations of heavy downpour and promoting land more permeable
Increased annual average temperature	Berlin	Cool pavement
Increase in average monthly daily maximum temperatures	Madrid	Tree planting and/or creation of green space
Increase in average monthly daily minimum temperatures	Madrid	Tree planting and/or creation of green space
Increased wind speeds	Moscow	Crisis planning and practice exercises
Less freezes	Berlin	Other
Occurrence of inundation and coastal overtopping	Porto	Community engagement/education
Susceptibility to cold waves	Porto	Community engagement/education
Warmer winters	Padua	Disease prevention measures

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