



European
Commission

JRC TECHNICAL REPORTS

Covenant of Mayors: key criteria for adaptation to climate change in local plans

Yeray Hernandez
Silvia Rivas
Paulo Barbosa

2017

This publication is a Technical report by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It aims to provide evidence-based scientific support to the European policymaking process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

Contact information

Name: Yeray Hernandez

Address: Via Fermi, 2749, 21027 Ispra (VA) – Italy, Building 100 – Office 1107

Email: yeray.hernandez@ec.europa.eu

Tel.: +39 0332 78 **3821**

JRC Science Hub

<https://ec.europa.eu/jrc>

JRC107395

EUR 28730 EN

PDF ISBN 978-92-79-71865-6 ISSN 1831-9424 doi:10.2760/432680

Luxembourg: Publications Office of the European Union, 2017

© European Union, 2017

The reuse of the document is authorised, provided the source is acknowledged and the original meaning or message of the texts are not distorted. The European Commission shall not be held liable for any consequences stemming from the reuse.

How to cite this report: Yeray Hernandez, Silvia Rivas and Paulo Barbosa, *Covenant of Mayors: key criteria for adaptation to climate change in local plans*, EUR 28730, doi:10.2760/432680.

All images © European Union 2017

Contents

- Abstract2
- 1 Introduction3
- 2 Essential requirements5
 - 2.1 Identification of current and future climatic hazards5
 - 2.1.1 JRC approach5
 - 2.2 Sectors to be covered: critical infrastructure6
 - 2.2.1 JRC approach7
 - 2.3 Stakeholders and citizen participation8
 - 2.3.1 JRC approach 12
 - 2.4 Maladaptation actions must be avoided 12
 - 2.4.1 JRC approach 14
 - 2.5 Economics of adaptation 14
 - 2.5.1 JRC approach 15
- 3 Conclusions 17
- References 18
- List of figures 21
- List of tables 22

Authors

Yeray Hernandez

Silvia Rivas

Paulo Barbosa

Abstract

Global warming has been stated to be unequivocal and human influenced. The emissions and atmospheric concentrations of greenhouse gases have increased to a degree that they are producing disturbances to the world climatic system. Several climate change impacts have occurred, while others will occur or will be intensified in the future. Ocean acidification, sea-level rise and extreme weather events are some of the projected impacts which, in addition, might have negative effects on the environment, society and the economy. These effects need to be addressed in order to reduce vulnerability to climatic hazards by means of climate change adaptation planning. However, adaptation is a rather unknown topic for many cities that have been focusing more on climate change mitigation.

The new Covenant of Mayors (CoM), launched in 2015, includes adaptation to climate change as one of the three main pillars of local action towards 2050: mitigation, adaptation and secure affordable and sustainable access to Energy. The covenant signatories share a common vision to 2050 based on:

- Decarbonised territories, thus contributing to keeping average global warming well below 2°C above pre-industrial levels, in line with the international climate agreement reached at COP 21 in Paris in December 2015.
- More resilient territories, thus preparing for the unavoidable adverse impacts of climate change.
- Universal access to secure, sustainable and affordable energy services for all, thus enhancing quality of life and improving energy security.

The JRC, as technical and scientific support actor should assure the CoM soundness and provide guidance to support climate change adaptation planning and implementation to signatory cities. The aim of this report is to establish the rationale behind the essential requirements for successful adaptation in the frame of the CoM, based on literature review and Joint Research Centre's knowledge on climate change adaptation. The results of this report highlight the need for identification of current and future climatic hazards, an inventory of critical infrastructure, active stakeholder and citizen participation, maladaptation avoidance, and an estimation of adaptation action costs.

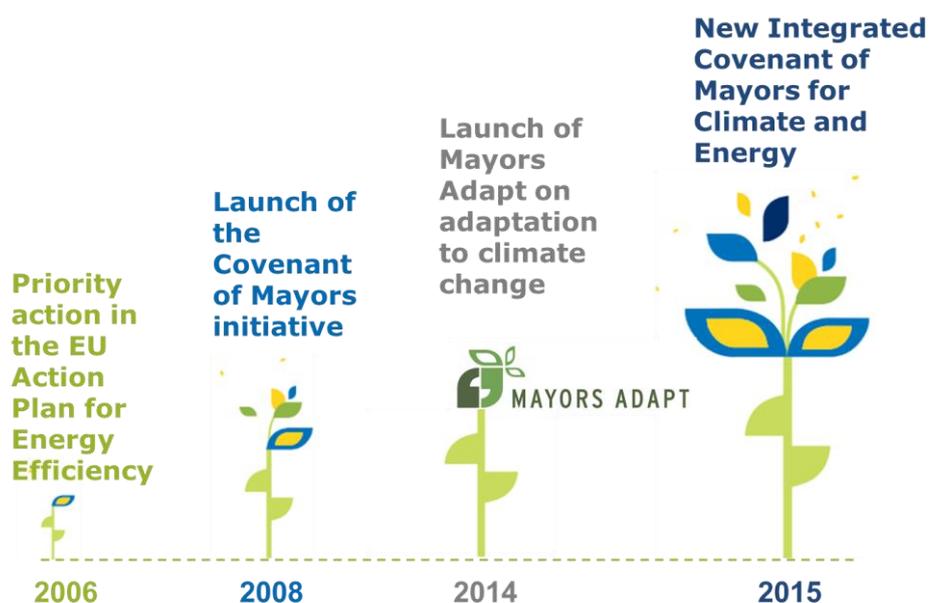
1 Introduction

Global warming has been stated to be unequivocal and human influenced (IPCC, 2013). The emissions and atmospheric concentrations of greenhouse gases (GHG) have increased by 40% compared to industrial levels, producing disturbances to the world climatic system. Several climate change impacts have occurred, while others will occur or will be intensified in the future. Ocean acidification, sea-level rise and extreme weather events are some of the projected impacts which, in addition, might have negative (or in some cases positive) effects on the environment, society and the economy.

These effects need to be addressed in order to reduce vulnerability to climatic hazards (EEA, 2013; IPCC, 2014a). In fact, adaptation has become an unavoidable strategy, especially if the consequences of an already warmed planet are considered (IPCC, 2013). Following this trend, in 2015 the CoM initiative (gathering local governments towards a low carbon future) included the adaptation to climate change as a main pillar together with mitigation to climate change and secure affordable and sustainable access to energy (see Fig. 1). Since the launch of the initiative, back in 2008, the Joint Research Centre has been in charge of the methodological developments of the Initiative and also in charge of the acceptance procedure of the Sustainable Energy Action Plans (SEAP) submitted by signatories and based on six basic criteria regarding mitigation purposes:

1. The SEAP must be approved by an official body (in principle the municipal council).
2. The SEAP must clearly specify your overall CO₂ reduction objective by 2020 (20% as a minimum).
3. The results of the Baseline Emission Inventory (BEI) must be provided and must cover the key sectors of activity.
4. The SEAP must include a set of actions in the key sectors of activity.
5. The SEAP template must be correctly filled-in.
6. The data inserted in the SEAP template must be coherent and complete.

Figure 1. New Covenant of Mayors initiative (2015)



Source: own elaboration.

With the extension of the covenant to adaptation purposes, yet the first priority is to deliver useful guidance to support adaptation planning and implementation to signatory cities as well as and to develop a robust acceptance system for the adaptation part of the plans.

In order to provide specific guidance for adaptation planning, a list of essential requirements should be proposed. The aim of this report is to provide the rationale on which the essential requirements that any adaptation plan should have with the purpose of being successful. The proposed list of key criteria, based on both a literature review and Joint Research Centre's knowledge and experience, are:

- Identification of current and future climatic hazards.
- Inventory of critical infrastructure.
- Active stakeholder participation.
- Maladaptation avoidance.
- Estimation of adaptation action costs.

The next sections are devoted to discuss each topic. At the end of each section a proposal for a list of essential requirement to be considered by the cities will be presented.

2 Essential requirements

2.1 Identification of current and future climatic hazards

Most of the cities have been subject to different climatic hazards during their history. This means that they should have a good understanding of which are the climatic hazards that have affected them through time. Climatic hazards are linked to the occurrence of extreme weather events, which in turn are related to a number of physical variables such as temperature, precipitation, or wind. Extreme weather events can lead to well-known natural hazards such as river and coastal floods, droughts, wildfires, heat and cold waves, windstorms; these climatic hazards have a direct impact on people's well-being and on a number of economic sectors such as agriculture, energy, transport, health, tourism, etc. Other effects of climate change can lead to hazards that are not directly linked to extreme weather but more to longer-term processes such as sea level rise, which will directly affect coastal cities.

There is however a big challenge ahead which is to better understand and quantify how will climate change impact on the intensity and frequency of extreme weather events. The latest report of the IPCC on climate extremes and disaster risk management has identified as far as possible the expected trends (increase and decrease) of extreme events and the need to adapt by reducing exposure and vulnerability (IPCC, 2012). Since the models used are global, it is difficult to downscale these trends at the level of cities. However the results of analysis of future climate extremes can be useful for cities to understand what are the general trends and if they should expect to suffer an increase or decrease of natural hazards in their region. Other results on the expected impact of climate change on different natural hazards can be found in the literature, both in scientific peer-reviewed journals or in technical reports (e.g. Ciscar et al., 2014). The forthcoming PESETA III report of the Joint Research Centre might be useful in this context.

2.1.1 JRC approach

The main climatic hazard risks to be considered by the Covenant of Mayors' signatories are, among others, the following:

- Extreme heat.
- Extreme cold.
- Extreme precipitation.
- River floods.
- Flash floods.
- Coastal floods.
- Sea level rise.
- Droughts.
- Storms.
- Landslides.
- Wildfires/Forest fires.
- Wind storms.
- Avalanches.

Not all the cities will have the same hazards and maybe some cities might come up with different types of hazards that are not included in this list. It will be important to include information based on historical hazards and on the cities perception of the current trend and future expectations.

2.2 Sectors to be covered: critical infrastructure

The European Environment Agency defines critical infrastructure as those infrastructures related to electricity, water supply and emergency services (EEA, 2012). Whereas, the IPCC gives a broader definition: «assets (physical or electronic) that are vital to the continued delivery and integrity of essential services on which a country relies, the loss or compromise of which would lead to severe economic or social consequences or to loss of life» (IPCC, 2014b, p. 1291). Concretely, the IPCC refers to critical infrastructure as water and sanitation infrastructure, energy (power generation and power distribution networks), transportation (roads, rails, airports, bridges, and related infrastructure), water supply (drainage systems), communications technology, police forces, and healthcare systems (hospitals, clinics and emergency responders) (IPCC, 2014a).

The JRC also provided a definition for critical infrastructure as «existing transport systems (roads, railways, airports, ports, and inland waterways), energy production (renewable and non-renewable energy power plants) and transmission (electricity distribution and transmission infrastructures, gas pipelines) systems, heavy industries (metal, chemical, mineral + refineries), water and waste treatment facilities, and social infrastructures (education and health)» (Forzieri et al., 2015, p. 10). Other definitions refers to critical infrastructure as «a collective term for assets essential to the functioning of society and where prolonged disruption would result in a negative economic impact» such as «education, healthcare, transport, utilities and communications» (Chapman et al., 2013).

The Critical Infrastructure Directive (CID) defines critical infrastructure as «an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions» (OJEU, 2008).

In Table 1 a summary of the assets that form critical infrastructure is presented. It is clear that there is no agreement regarding what critical infrastructure means and implies. As a consequence of this, the JRC will adopt a flexible approach for the proposal of essential requirements concerning critical infrastructure. They are given in next section.

Table 1. Critical infrastructure assets.

	IPCC	EEA	JRC	CID	CoM
Water facilities:		X	X		X
- Sanitation	X				
- Drainage	X				
Waste treatment facilities			X		X
Energy:		X			
- Power generation	X		X	X	X
- Power distribution networks	X		X	X	X
Heavy industries:					
- Metal			X		
- Chemical			X		
- Mineral + refineries			X	X	
Transport:					
- Roads	X		X	X	X
- Railways	X		X	X	X
- Airports	X		X	X	
- Ports			X	X	X
- Bridges	X				
- Island waterways			X	X	
- Pipelines			X	X	
- Ocean and short-sea shipping				X	
Communication technologies	X				
Security:				X	
- Policy forces	X				
Education			X		X
Healthcare systems:			X	X	
- Hospitals	X				
- Clinics	X				
- Emergency services	X	X			

Source: own elaboration.

2.2.1 JRC approach

The critical infrastructures proposed to be covered by the CoM's Adaptation plans should consist of:

- Communication technologies.
- Education.
- Energy.

- Healthcare systems, such as hospitals, clinics, and emergency services.
- Heavy industries.
- Security.
- Transport.
- Waste treatment.
- Water.

Since the signatories may not have all the aforementioned facilities, or may be affected by them under specific climate disasters, the JRC would recommend:

- An inventory of all existing critical infrastructure available within the Municipality that should be protected, as well as those critical infrastructures located beyond the city boundaries that may put the city at risk under climatic disasters (e.g. heavy industries).
- Level of risk for each critical infrastructure facility. The hazards may be one or multiple.

2.3 Stakeholders and citizen participation

A stakeholder interested in adaptation planning might be defined as those «representatives of local (and regional) actors whose interests ... may be affected by future climate impacts and/or planned adaptation measures» (EEA, 2016, p. 122).

Stakeholders should be considered in decision-making processes since they are powerful problem-solving tools (Banville et al., 1998). Stakeholders have also been considered as basic requisite to cope with the complexities of the issues involved (Funtowicz and Ravetz, 1991, 1993). Climate change adaptation planning needs to include participatory processes (Watkiss and Helfgott, 2015), in order to look for solutions that reduce vulnerability and increase resilience not only in the short-term, but also in the long-run (Gain and Giupponi, 2015). Andersson et al. (2015) mentioned that the involvement of stakeholders in climate change adaptation planning is a useful tool to propose possible measures, and assess strategies in order to make decisions implementable.

In order to develop successful adaptation planning, multiple stakeholder engagement is required «to interact and collaborate coherently across different sectors and levels of government» (EEA, 2016, p. 8). «Supportive and well-tailored governance that covers horizontal and vertical engagement and broad stakeholder participation is a basic condition for all steps of the adaptation planning, implementation and monitoring process as is awareness and tailored knowledge creation» (EEA, 2016, p. 10). «If a wide range of stakeholders participate, including business, communities and citizens, the city can benefit from social innovation. Their innovative ideas and changing social relationships can play a positive role in urban adaptation» (EEA, 2016, p. 31). Therefore, «good governance includes stakeholder engagement to ensure that urban adaptation policies and actions are transparent and legitimate, and to make sure that local stakeholders are committed to implementing them» (EEA, 2016, p. 50).

Stakeholder and citizen engagement should be carried out since the very first steps of the adaptation planning process until the end of it (Hernández-González and Corral, 2017; Corral and Hernandez, 2017). «Ideally, city authorities [should] start to involve stakeholders as soon as they begin considering adaptation to develop a strategy and implementation plan. This produces well-informed policies and creates ownership among stakeholders» (EEA, 2016, p. 79). Moreover, stakeholders' participation should imply deeper participation engagement approaches rather than the provision of information and consulting opinions (EEA, 2016; see also Table 2 for levels of participation). It rather needs deep engagement (Kuik et al., 2016), in order to climb further up the ladder to levels of citizen power (Arnstein, 1969).

The stakeholders to be engaged should belong to the public sector (planning authorities, water authorities, health services, social services, housing authorities and agencies concerned with disaster risk management), the private sector (urban service and utility providers, business, investors, private homeowners and consultants) and other stakeholders (citizen initiatives and community organisations) (EEA, 2016). Therefore, «stakeholder involvement in urban adaptation planning and implementation entails engaging representatives of local (and regional) actors whose interests that may be affected by future climate impacts and/or planned adaptation measures. Therefore, besides representatives of public authorities, relevant stakeholders include local business and the private sector, specific interest groups (e.g. NGOs), scientists/researchers and the general public» (EEA, 2016, p. 122).

A recent adaptation case study carried out by the JRC (still to be finished) have included a broad-plural list of stakeholders and citizens to start developing the first steps of different adaptation pathways for 2040 (Hernández-González et al., 2016; Hernandez et al., 2017). The invited stakeholders to actively participate were the following:

- Experts in climate change:
 - Universities.
 - Research centres.
 - Scientific reporters.
- Decision-makers:
 - Regional governments.
 - Department for Pollution Prevention.
 - Department for Public Health.
 - Local governments:
 - Department for the Environment.
 - Department for Civil Protection.
 - Municipality Union Platform.
- Employers' organizations:
 - Entrepreneurs.
 - Chamber of Commerce.
 - Research & Development State Company.
- Trade unions:
 - Regional.
 - Local.
- NGOs:
 - Environmentalists.
 - Citizens interested.

However, due to the stakeholders engagement is case study-dependent, and there is a lack of indicators to monitor these processes (Rauschmayer et al., 2009), the JRC approach for this essential requirement for participation will also be flexible. It is explained below.

Table 2. Levels of citizen participation in decision-making.

Levels	Arnstein, 1969	IAP2
Manipulation	People are placed on rubberstamp advisory committees for the express purpose of "educating" them or engineering their support.	---
Therapy	Under a masquerade of involving citizens in planning, the experts subject the citizens to clinical group therapy.	---
Inform	Informing citizens of their rights, responsibilities, and options. However, too frequently the emphasis is placed on a one-way flow of information - from officials to citizens - with no channel provided for feedback and no power for negotiation. Under these conditions, particularly when information is provided at a late stage in planning, people have little opportunity to influence the program designed "for their benefit." The most frequent tools used for such one-way communication are the news media, pamphlets, posters, and responses to inquiries.	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives and/or solutions.
Consult	Inviting citizens' opinions, like informing them, can be a legitimate step toward their full participation. But if consulting them is not combined with other modes of participation, it is still a sham since it offers no assurance that citizen concerns and ideas will be taken into account. When powerholders restrict the input of citizens' ideas solely to this level, participation remains just a window-dressing ritual.	To obtain public feedback on analysis, alternatives and/or decision.
Placation	It is at this level that citizens begin to have some degree of influence though tokenism is still apparent. An example is the Model Cities advisory and planning committees. They allow citizens to advise or plan <i>ad infinitum</i> but	---

	retain for powerholders the right to judge the legitimacy or feasibility of the advice.	
Involve	---	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.
Collaboration / Partnership	Power is in fact redistributed through negotiation between citizens and powerholders. They agree to share planning and decision-making responsibilities through such structures as joint policy boards, planning committees and mechanisms for resolving impasses. After the ground rules have been established through some form of give-and-take, they are not subject to unilateral change. Now citizens have some genuine bargaining influence over the outcome of the plan (as long as both parties find it useful to maintain the partnership).	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.
Delegated power	Negotiations between citizens and public officials can also result in citizens achieving dominant decision-making authority over a particular plan or program. Citizens hold the significant cards to assure accountability of the program to them.	---
Citizen control / Empower	Participants or residents can govern a program or an institution, be in full charge of policy and managerial aspects.	To place final decision-making in the hands of the public.

Source: own elaboration based on Arnstein (1969) and IAP2 (2017).

2.3.1 JRC approach

Stakeholders to be engaged in CoM Adaptation plan should be:

- Experts in climate change.
- Public sector:
 - Planning authorities.
 - Authorities concerned with disaster risk management.
- Private sector:
 - Business organisations.
 - Trade unions.
- Other stakeholders:
 - NGOs.
 - Citizens.

Since the stakeholders engaged depend on the specific cases and local characteristics, the JRC would recommend:

- An inventory of all relevant stakeholders and citizens, following, at least, the previous given list.
- It should be indicated if the stakeholders and citizens considered relevant in the inventory have been engaged or not. According to the literature reviewed above, the essential acceptable level of engagement should be, at least, the following:
 - *Level 1: Involvement.* To work directly with the public throughout the adaptation strategy to ensure that public concerns and aspirations are understood and considered.
 - *Level 2: Collaboration.* To partner with the public in each aspect of the adaptation strategy such that planning and decision-making responsibilities are shared, e.g. the development of alternatives and the identification of the preferred solution.
 - *Level 3: Delegated power.* Negotiations between citizens and public officials result in citizens' dominant decision over the adaptation strategy.
 - *Level 4: Citizen control.* Participants govern the adaptation strategy. They are in full charge of policy and managerial aspects. Therefore, final decision-making is in the hands of the public.
- If some stakeholder(s) did not participate in some stage or did not participate at all, an explanation of why they were left out of the adaptation strategy should be given.
- A table summarising the phases where the stakeholders have been participating should also be provided. The stakeholders mentioned in the list should have been participating in the whole process and all the adaptation strategy steps.

2.4 Maladaptation actions must be avoided

According to Barnett and O'Neill (2010, p. 211), maladaptation is defined as the «action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups». The IPCC has

also given a definition for maladaptation as those «actions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future» (IPCC, 2014b, p. 1769). Meanwhile, Juhola et al. (2016, p. 139) define it as «a result of an intentional adaptation policy or measure directly increasing vulnerability for the targeted and/or external actor(s), and/or eroding preconditions for sustainable development by indirectly increasing society's vulnerability».

Barnett and O'Neill (2010) argue that there are five types of maladaptation actions:

- Those increasing emissions of GHG: energy-intensive adaptation actions may imply more GHG released to the atmosphere. Examples of maladaptation are energy-intensive air conditioners in response to heatwaves, or desalination plants for water supply based on fossil fuel production.
- Those disproportionately burdening the most vulnerable: adaptation actions carried out to protect one sector or group that increase the vulnerability of those most at risk, such as minority groups or low-income families. For example, adaptation projects that imply increasing prices to lower income families.
- Those with high opportunity costs: adaptation actions that their economic, social, or environmental costs are higher than other alternative options.
- Those actions that reduce incentive to adapt: adaptation actions that their implementation keeps people behaving in such a way that increases vulnerability to climate change. For example, the introduction of new technologies that reduce water prices, that induces increasing water use.
- Those actions inducing path dependency: adaptation actions that their implementation implies large infrastructural capital commitments, leading to institutions to trajectories difficult to change in the future, since flexibility to respond to unforeseen climatic, environmental, economic and social changes have decreased.

Juhola et al. (2016, p. 136-137) redefine the concept of maladaptation. They consider that there are three different types of maladaptation:

- Rebounding vulnerability: «adaptation action that increases current or future climate change vulnerability of the implementing actor (or the targeted actor(s) if implemented by e.g. a local government). The actor(s) can be affected in three different ways; through increasing exposure; or increasing sensitivity; or by decreasing the actors' adaptive capacity». Some examples are:
 - Increased exposure: «trees planted to provide shade that damage buildings in case of a storm».
 - Increased sensitivity: «introduction of new tree species to cope with climate change that increases sensitivity».
 - Decreased adaptive capacity: «resettlement of small island state inhabitants leading to lower adaptive capacity due to unemployment, homelessness, landlessness, food insecurity, social marginalisation, reduced access to common-property resources and increased morbidity».
- Shifting vulnerability: an adaptation action that «increases current or future vulnerability for one or several external actors. The external actors' vulnerability can be affected through increased exposure or sensitivity, or by decreased adaptive capacity». Some examples are:
 - Increased exposure: «coastline armouring or infrastructure that leads to coastal erosion elsewhere».

- Increased sensitivity: «development of floodplains leading to reduced buffering capacity for river water».
 - Decreased adaptive capacity: «development of desalination plants to adapt to drinking water deficiency leading disproportionately high cost for low income water users».
- Eroding sustainable development: «an adaptation action that increases GHG emissions and negatively impacts environmental conditions and/or social and economic values».
- Increased GHG emissions: «development of artificial snow for skiing that increases GHG emissions».
 - Environmental degradation: «wood heating to make households less vulnerable to power outages leading to smog and negative respiratory health effects».
 - Negative economic and social externalities: «resource concentration, land grabbing, aggravated social poverty».

2.4.1 JRC approach

The essential requirements for maladaptation should consist of, at least, the following:

- Adaptation planning should be CO₂-e neutral, i.e. some actions may increase CO₂-e emissions as long as they are compensated by other actions such that total CO₂-e emissions are zero or negative.
- Environmental degradation should be avoided. Each action should have an environmental impact assessment approval.

2.5 Economics of adaptation

Generally speaking, there are three assessment techniques to compare alternative actions: they are cost-benefit analysis, cost-effectiveness analysis, and multi-criteria analysis (EC, 2009). These three assessment methods have also been considered useful to compare adaptation policy options (Chiabai et al., 2015; EEA, 2016; Kuik et al., 2016; Rouillard et al., 2016a, 2016b; Tröltzsch et al., 2016).

Cost-benefit analysis (CBA) estimates all discounted costs and benefits of a project, all of them expressed in monetary terms. Thus, when benefits exceed costs the project is considered as desirable for society. Cost-effectiveness analysis (CEA) needs to explore alternative policy actions intended to achieve a determined target. Then, the financial costs of each alternative action is calculated. Therefore, assuming the same target for all alternative actions, the best option would be the one with lower associated costs. Lastly, multi-criteria analysis (MCA) compares alternative policy actions through an explicit set of objectives. Then, a certain range of criteria are considered so as to measure to what extent those objectives are achieved. This method may use monetary, biophysical, and qualitative criteria so as to compare the alternative policy actions.

These three assessment methods have advantages and disadvantages associated. They are presented in Table 3. MCA, however, has been considered «the best choice if several factors have values that are impossible to translate into money» (EEA, 2016, p. 94). Although, partial CBA (i.e. when only part of the costs and benefits can be monetised) may be integrated into MCA as one more criterion of the whole range of criteria (Gühnemann et al., 2012).

Table 3. Advantages and disadvantages of assessment techniques.

	Advantages	Disadvantages
CBA	Accounts for all (negative and positive) effects of actions Allows comparison of the ordering of costs with the ordering of benefits of the proposal over time Allows to rank alternative proposals in terms of their net social gains	Cannot include impacts for which there exist no quantitative or monetary data Needs to be supplemented by additional analysis to cover distributional issues
CEA	Does not require exact benefit measurement or estimation Can be used to compare alternatives that are expected to have more or less the same outcome	Does not resolve the choice of the optimal level of benefits Concentrates on a single type of benefit (the intended effect of the measure), but would lead to an incomplete result if possible side-effects would not be assessed Provides no clear result as to whether a regulatory proposal would provide net gains to society
MCA	Recognises multi-dimensionality of sustainability Allows different types of data (monetary, quantitative, qualitative) to be compared and analysed in the same framework with varying degrees of certainty Provides a transparent presentation of the key issues at stake and allows trade-offs to be outlined clearly; contrary to other approaches such as CBA, it does not allow implicit weighting Enables distributional issues and trade-offs to be highlighted	Includes elements of subjectivity, especially in the weighting stage where the analyst needs to assign relative importance to the criteria Because of the mix of different types of data, cannot always show whether benefits outweigh costs Time preferences may not always be reflected

Source: EC, 2009.

2.5.1 JRC approach

Even though MCA seems to be the best technique to compare actions according to the literature presented above (especially if partial CBA is integrated in MCA), the JRC will not recommend choosing any of these techniques, or any other, specifically. Adaptation planners need to select the methodology based on the specific characteristics of each case study.

However, there is a common practice in any of the assessment techniques presented above that may be considered: the estimation of costs of adaptation actions, considered as the investment and maintenance costs of their implementation.

Therefore, according to the JRC, the essential requirements for economics of adaptation is:

- An estimation of the investment and maintenance costs of all proposed adaptation actions. Hence, there should not be a proposal of actions without an estimation of its implementation costs.
- Actions should have a time horizon for their implementation.

— Actions should have allocated funding.

3 Conclusions

Adaptation has become an unavoidable strategy to tackle climate change. However, it probably is a rather not well-known topic for many cities. The JRC, as methodological actor on the Covenant of Mayors initiative needs to deliver useful guidance to support adaptation planning and implementation to signatory cities. In order to provide this guidance, a list of essential requirements has been proposed in this report. The list of those essential requirements involves identification of current and future climatic hazards, critical infrastructure, stakeholder and citizen participation, maladaptation avoidance, and estimation of adaptation action costs.

First, cities should be aware not only of the main climatic hazards there are currently facing but also about the projected trends in the future. Secondly, they should have an updated inventory of the critical infrastructures that are needed to provide public services to their inhabitants. Moreover, they should be aware of other critical infrastructure as well (that may not be within the city boundaries) and may affect the city under a climatic disaster event. Thus, having an inventory of the existing critical infrastructure and their level of risk is essential.

Developing this inventory will also be useful to identify public and private stakeholders potentially affected by the impacts of climatic hazards. These stakeholders should be actively involved in adaptation planning from the very beginning. Their involvement should guarantee the inclusion of all perspectives in adaptation planning, as well as sensitive topics for local communities such as equity, justice, and the sustainability of adaptation actions.

Another element to be considered as an essential requirement is to avoid maladaptation. Implementing adaptation actions may imply additional environmental impacts or increase vulnerability elsewhere, for instance. These downside effects highlight that we would not be talking about adaptation, but maladaptation. Therefore, any adaptation action should avoid negative effects.

Lastly, even though there are different assessment techniques to compare adaptation alternative actions (such as cost-benefit analysis, cost-effectiveness analysis, and multi-criteria analysis), all actions proposed should have at least an associated estimation of its investment and maintenance costs.

References

- Andersson-Sköld, Y., Thorsson, S., Rayner, D., Lindberg, F., Janhäll, S., Jonsson, A., . . . Granberg, M. (2015). An integrated method for assessing climate-related risks and adaptation alternatives in urban areas. *Climate Risk Management*(7), 31-50.
- Arnstein, S. R. (1969). A Ladder of Citizen Participation. *Journal of the American Institute of Planners*, 35(4), 216-224.
- Banville, C., Landry, M., Martel, J.-M., & Boulaire, C. (1998). A stakeholder approach to MCDA. *Systems Research and Behavioral Science*, 15(1), 15-32.
- Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change*(20), 211-213.
- Chapman, L., Azevedo, J. A., & Prieto-Lopez, T. (2013). Urban heat & critical infrastructure networks: A viewpoint. *Urban Climate*(3), 7-12.
- Chiabai, A., Hunt, A., Galarraga, I., Lago, M., Rouillard, J., Sainz de Murieta, E., . . . Watkiss, P. (2015). *Using cost and benefits to assess adaptation options*. ECONADAPT - The Economics of Adaptation.
- Ciscar, J., Feyen, L., Soria, A., Lavalle, C., Raes, F., Perry, M., . . . Ibarreta, D. (2014). *Climate Impacts in Europe. The JRC PESETA II Project*. Luxembourg: Publications Office of the European Union.
- CoM. (2010). *How to develop a Sustainable Energy Action Plan (SEAP) - Guidebook*. Luxembourg: European Union.
- Corral, S., & Hernandez, Y. (2017). Social Sensitivity Analyses Applied to Environmental Assessment Processes. *Ecological Economics*(141), 1-10.
- EC. (2009). *Impact Assessment Guidelines*. Brussels: European Commission.
- EEA. (2012). *Urban adaptation to climate change in Europe - Challenges and opportunities for cities together with supportive national and European policies*. Copenhagen: European Environment Agency.
- EEA. (2013). *Adaptation in Europe: Addressing risks and opportunities from climate change in the context of socio-economic developments*. Copenhagen: European Environment Agency.
- EEA. (2016). *Urban adaptation to climate change in Europe 2016: Transforming cities in a changing climate*. Copenhagen: European Environment Agency.
- Forzieri, G., Bianchi, A., Marin-Herrera, M. A., Batista e Silva, F., Feyen, L., & Lavalle, C. (2015). *Resilience of large investments and critical infrastructures in Europe to climate change*. Luxembourg: Joint Research Centre.
- Funtowicz, S. O., & Ravetz, J. R. (1991). Ecological Economics: the science and management of sustainability. In R. Costanza (Ed.), *A New Scientific Methodology for Global Environmental Issues* (pp. 137-152). New York: Columbia University Press.
- Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739-755.
- Gain, A. K., & Giupponi, C. (2015). A dynamic assessment of water scarcity risk in the Lower Brahmaputra River Basin: An integrated approach. *Ecological Indicators*(48), 120-131.
- Gühnemann, A., Laird, J. J., & Pearman, A. D. (2012). Combining cost-benefit and multi-criteria analysis to prioritise a national road infrastructure programme. *Transport Policy*(23), 15-24.

- Hernandez, Y., Guimarães Pereira, Â., Panella, F., & Barbosa, P. (2017). *Focus groups desarrollados en Tenerife para la elaboración de escenarios de adaptación al cambio climático: transcripciones completas*. Luxembourg: Joint Research Centre.
- Hernández-González, Y., & Corral, S. (2017). An extended peer communities' knowledge sharing approach for environmental governance. *Land Use Policy*(63), 140-148.
- Hernández-González, Y., Guimarães Pereira, Â., Rodríguez, S., Cuevas, E., & Barbosa, P. (2016). *Perspectives on contentions about climate change adaptation in the Canary Islands: A case study for Tenerife*. Luxembourg: Joint Research Centre.
- IAP2. (2017, February 6). *Public Participation Spectrum*. Retrieved from International Association for Public Participation: <http://iap2canada.ca/page-1020549>
- IPCC. (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. (C. V.-K. Field, Ed.) Cambridge, UK, and New York, NY, USA: Cambridge University Press.
- IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (T. D.-K. Stocker, Ed.) Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- IPCC. (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (C. V. Field, Ed.) Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- IPCC. (2014b). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- Juhola, S., Glaas, E., Linnér, B.-O., & Neset, T.-S. (2016). Redefining maladaptation. *Environmental Science & Policy*(55), 135-140.
- Kuik, O., Scussolini, P., Mechler, R., Mochizuki, J., Hunt, A., & Wellman, J. (2016). *Assessing the economic case for adaptation to extreme events at different scales*. ECONADAPT project.
- OJEU. (2008). *COUNCIL DIRECTIVE 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection*. Brussels: Official Journal of the European Union.
- Rauschmayer, F., Berghöfer, A., Omann, I., & Zikos, D. (2009). Examining Processes or/and Outcomes? Evaluation Concepts in European Governance of Natural Resources. *Environmental Policy and Governance*(19), 159–173.
- Rouillard, J., Tröltzsch, J., Lago, M., Markandya, A., Sainz de Murieta, E., & Galarraga, I. (2016a). *Distributional objectives and non-monetary metrics*. ECONADAPT - The Economics of Adaptation.
- Rouillard, J., Tröltzsch, J., Tarpey, J., Lago, M., Watkiss, P., Hunt, A., . . . Scussolini, P. (2016b). *The economic analysis of climate adaptation: Insights for policy-makers*. ECONADAPT - The Economics of Adaptation.
- Tröltzsch, J., Rouillard, J., Tarpey, J., Lago, M., Watkiss, P., & Hunt, A. (2016). *The economics of climate change adaptation: Insights into economic assessment methods*. ECONADAPT - The Economics of Adaptation.
- Watkiss, P., & Helfgott, A. (2015). *Stakeholder Selection and Survey Results*. ECONADAPT - The Economics of Adaptation.

List of figures

Figure 1. New Covenant of Mayors initiative (2015)..... 3

List of tables

Table 1. Critical infrastructure assets. 7
Table 2. Levels of citizen participation in decision-making.....10
Table 3. Advantages and disadvantages of assessment techniques.15

***Europe Direct is a service to help you find answers
to your questions about the European Union.***

Freephone number (*):

00 800 6 7 8 9 10 11

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

More information on the European Union is available on the internet (<http://europa.eu>).

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
via EU Bookshop (<http://bookshop.europa.eu>);
- more than one copy or posters/maps:
from the European Union's representations (http://ec.europa.eu/represent_en.htm);
from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
by contacting the Europe Direct service (http://europa.eu/eurodirect/index_en.htm) or
calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (<http://bookshop.europa.eu>).

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.



EU Science Hub
ec.europa.eu/jrc



@EU_ScienceHub



EU Science Hub - Joint Research Centre



Joint Research Centre



EU Science Hub



Publications Office