Podgorica
Climate Change Adaptation

Vulnerability Assessment and Adaptation Action Plan

FINAL DRAFT REPORT

8 July 2015

Contents

ANNEXES

LIST OF TABLES:

LIST OF FIGURES:

Project and edition details

Capital City of Podgorica, Montenegro:

Secretariat for Spatial Planning and Environmental Protection

The report was prepared within the framework of the project:

Climate Change Adaptation in Western Balkans (CCAWB)

Implemented by:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, on behalf of German Federal Ministry for Economic Cooperation and Development (BMZ)

Edited by:

- Working Group for Adaptation to Climate Change of the Capital City of Podgorica
- Sasa Karajovic (local consultant)
- INFRASTRUKTUR & UMWELT Professor Böhm and Partner (German consultancy)

Project duration:

December 2013 – April 2015

Preface

As a continuously evolving urban system, the Capital City of Podgorica is subject to various climate change impacts, which requires responsible action in order to define appropriate measures and take concrete steps. Aware of the wealth of natural resources that characterizes our city, we are developing mechanisms for their preservation and improvement, all of which serves the healthy environment.

We consider participation in the project "Climate change adaptation in the Western Balkans", implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and supported by the German consulting company "Infrastruktur & Umwelt Professor Böhm und Partner", within which this document was developed, to be a valuable contribution to our actions in this field. A particularly important project component is the cooperation with other cities in the region, as a quality prerequisite for a more comprehensive approach to solving the identified problems and implementing appropriate activities.

Through the implementation of project activities, we have mobilized our own capacities, analysed the situation in various sectors in the context of exposure and vulnerability to extreme weather events and recognized the relevant measures of adaptation to expected climate change. Implementation of defined activities will contribute to the resilience of our urban system to changes in climate parameters, including the preservation of the environment and improvement of the quality of life of citizens.

As a result of months of efforts, we have formulated the document before you, which will, we believe, be a useful and inspiring guide for a more complete implementation of all forms of future activities, not only for workers engaged in the field of environmental protection.

One of the main objectives of the Climate Change Adaptation Strategy is to offer mechanisms for increasing capacities to adapt to natural and man-made systems, based on the degree of their vulnerability. The problem to be addressed is to increase the availability of the system to respond to changes instead of reacting to undesirable impacts that have been caused precisely by climate change.

The adaptation capacity is an indicator which shows at what level should be the degree of concern and in which direction we should act, especially in terms of increasing capacities. Exchange of knowledge and experiences and "lessons learned" are always a good basis for achieving the set objectives.

Given that the area of the Capital City of Podgorica has been marked as already built urban system, the adaptation capacities are related to the ability to use the experience gained and be open to new innovative solutions. Increased ability to adapt is achieved precisely by applying various measures as responses to climate change. The above implies improving the management and information sharing in order to create a satisfactory level of common knowledge, dedication to the treatment of outstanding issues and general communication between partners. An undeniable component is certainly the economic and financial measures, as well as the involvement of all stakeholders (horizontal and vertical integration), capacity building and awareness raising.

Finally, I want to stress that the motto we adopted during work on this document is that adaptation measures are to be viewed as an investment into the future, not a cost at the present time. If the planned scenario of climate change does not happen, the use of identified measures will certainly result in improving the quality of the living environment and thus in a richer heritage to be left to the future generations.

Slavoljub Stjepović
Mayor of the Capital City of Podgorica

1. Objectives and background

1.1. Objectives of a climate change adaptation strategy

The overall objective of the project "Climate change adaptation in the Western Balkans" was to integrate climate change adaptation (CCA) into the management and planning processes within the different sectors of the city administration, particularly cross-cutting activities like spatial planning and strategic project development. The project aimed at short-, medium- and long-term perspectives. Under the patronage of the mayor of Podgorica, who nominated the city's Secretariat for Spatial Planning and Environmental Protection for the coordination of the activities, a working group consisting of representatives of all relevant institutions carried out a vulnerability assessment and action plan.

Adaptation to climate change is a continuous long term process that has no real start or end date. Thus the results documented in this report should be seen as interim results on the long way to adaptation. They shall allow the city administration to take into account, in an adequate way, the potential influence of climate change and improve the important decisions for the development plans and programs. In any case, the interim results will be used as recommendation and guidance for decision makers in their political and administrative work in the city. It must be taken into account that the measures from the Action Plan in this report cannot be a "stand-alone policy", for their implementation is in close relation with sector plans and project initiatives.

Consequently, the purpose of drafting this document is, on the basis of available data, information and results, to analyse, identify, create and, through Action Plan, document the interventions for adaptation to climate change options.

1.2. Situation and developments in Podgorica

Podgorica is the capital and largest city of Montenegro, which covers the area of approximately 1,508km^2, or 10.7% of the territory of Montenegro.

Data from the last census in 2011 show that Podgorica has 187,085 inhabitants, which represents 30% of the Montenegrin population.

There are two urban municipalities (Tuzi and Golubovci) in the territory of the Capital City and 141 rural settlements with 66 local communities.

Podgorica is the main roads intersection in Montenegro. It has a very convenient location at the confluence of the Ribnica with the Morača River, in the Zeta-Bjelopavlići plain. The city is close to the ski centres in the north of the country and to the seaside resorts on the Adriatic Sea. The Skadar Lake National Park is also located nearby.

Spatial and Urban Plan of Podgorica

The area of the Capital City of Podgorica was covered by the Spatial and Urban Plan (SUP), which was adopted in 2014 for the entire territory of the capital city.

The general objectives of the capital city's SUP are:

- Encouraging a more balanced territorial development, rational organization, reservation and protection of space;
- Improving the quality of life that will be achieved by preventing excessive concentration of population in the capital city, by making sure Tuzi and Golubovci become part of the urban agglomeration of Podgorica;
- Increasing the accessibility of dispersed settlement network, development of urban municipalities of Tuzi and Golubovci, secondary centres, more balanced socio-economic development and in particular the development of rural areas;
- Providing conditions for regulation and development of areas and settlements;
- Promotion, activation and responsible management of the available natural and man-made resources, environment and cultural assets;
- Protection of settlements and land from flooding;
- Groundwater protection in the region to supply water to the population;
- Protection against earthquakes;
- Protection of public interest, areas and facilities of public interest, identification and protection of public goods;
- Inclusion of all actors and stakeholders in the adoption and implementation of strategic planning decisions, etc. (public, private, non-governmental sector);
- Proper use of human, natural and built (anthropogenic) potentials in socio-economic, spatial and ecological terms;
- Establishing an effective geographical information system of the SUP of the capital Podgorica for plan implementation needs, monitoring of protection, spatial use and development, etc.

Previous spatial development

The previous spatial development of Podgorica has distinctive features of urban and rural continuum:

- The central part of the city, with a large population density, is predominantly governed by the spatial and urban plan, with boulevards, parks, monumental bridges and buildings that give the appearance of a "big city" and very scattered facilities of low density, with a large percentage of illegally constructed buildings in the suburbs;
- Frequent changes (planned and unplanned) of land uses, and weak solutions for and discontinuity in the development of physical structures in the city, are more evident after 1991;
- Segregated housing after 1991 is even more pronounced. On the one hand, elite residential zones (Nova Varoš - Gorica; Novi Grad - Kruševac), and on the other predominantly workers' settlements with a large percentage of illegal structures (Malo Brdo, Zagorič, Kakaricka Gora, Dajbabska Gora, Masline, Konik - Vrela Ribnička), informal settlements (Zagorič - park-forest, Zagorič - Stara Zlatica) and refugee settlement Konik - Vrela Ribnička with extremely low standards of housing;

- Poor maintenance of residential settlements and collective construction facilities, from the end of the seventies and eighties (e.g., Block 5, Block 6 Kruševac, apartment blocks Drač-Zagorič) and inadequate projects for their revitalization and re-urbanization;
- Devastation of agricultural land (Lješkopolje, Momišićko Polje, Dajbabsko Polje...);
- Insufficient promotion of the natural environment and cultural heritage, devastation of shores of the rivers Morača and Ribnica, Zagorič Forest Park, illegal construction, deterioration of the historic core of the city, or inadequate typology of additions, inadequate treatment of cultural goods (Doclea, Ribnica fortress...).

Future spatial organization

The concept of spatial organization of the city tends to eliminate the main problems while preserving and developing the existing values and specificities of the Capital City of Podgorica, which we defined as spatial constants. The goal is evolution rather than a radical transformation of the existing urban areas.

The main objectives of the development of urbanization and settlements' network are:
- Smaller and more moderate growth of Podgorica, aimed at development within the existing construction land (*brownfield development*), in order to make a significant qualitative improvement of urban structures and of the living environment;
- Redirecting the process of uneven development in the network of settlements;
- Restructuring the network of rural settlements by a more rational agglomeration of population and activities, and encouraging the development of rural and mountainous areas towards a better utilization of natural potentials;
- Rapid development of rural areas, by creating conditions for the return of population.

Construction land will be planned on the principles of sustainable development, protection of natural resources and characteristics of landscapes, while taking into account the following guidelines:
- Giving priority to construction within the existing construction land, and in particular to the completion of unfinished parts, all in accordance with the capacities of the existing infrastructure and publicly used facilities;
- Adjusting the housing and population density by the type of settlement;
- Design of construction land appropriate to geomorphologic and hydrological preconditions as a separate unit of the settlement.

Forest areas are the most common general category in the area of the capital city (48.18%). The second category by representation is the other natural areas (16.33%). The surface areas of settlements (construction, non-construction land and construction land outside built-up areas of existing settlements) occupy 6.29% of the territory of Podgorica. Areas and corridors of transport infrastructure take up 3.11% of the total territory of the Capital City. Agricultural land, with arable agricultural land and other arable land, covers 14.60% of the total territory of the Capital City.

Protection and improvement of the environment

The development of the strategic environmental assessment happened in parallel with the development of the SUP. In the context of SUP's development and implementation, and

having considered the current priority policies and strategies in the field of environment, the following general objectives were singled out as particularly significant:

- Improvement of all segments and parts of the environment,
- **Efficient fight in the field of climate change,**
- Reducing the loss of biodiversity by 2020 ("Aichi Biodiversity Targets"),
- Achieving the goals of 20-20-20 - reducing greenhouse gas emissions by 20%, increasing energy efficiency also by 20% and increasing the share of energy from renewable sources by the same percentage.

Starting from the objectives set whose achievement implies improving the overall quality of the environment and in accordance with the nature and extent of identified potential adverse impacts that may result from SUP's implementation, the general measures of sustainable development were defined by sectors, as well as specific measures for individual segments and phenomena. Among others, the following measures stand out:

Mitigation and adaptation to climate change measures:

- Develop a study of vulnerability of the Capital City to climate change;
- Develop an adaptation strategy with the action plan for the Capital City;
- Develop a vulnerability assessment of areas particularly exposed to floods (as an obvious problem);
- Expand urban green areas in terms of their quantitative and qualitative increase in city blocks and the formation of protective greenery around infrastructure facilities;
- Assess possibilities for the development and application of "drop" irrigation system for the maintenance of public areas (parks, yards of city institutions and others);
- Conduct climate change adaptation and mitigation measures;
- Reduce the production of methane in illegal dumps by removing deposited waste.

Energy management measures:

- Develop a methodology and a study of and apply incentive schemes of the Capital City (grants, subsidies, etc.) for the construction and renovation of buildings under low-energy and passive standards;
- Use the existing city's incentive schemes and design new ones (grants, subsidies, etc.) for the use of renewable energy sources in buildings (photovoltaic systems, solar collectors, biomass boilers, heat pumps, etc.);
- Relocate traffic from Zone I;
- Improve the existing network of urban and suburban transport lines by introducing new lines or changing the route of lines, depending on the potential demand and optimization of transport services;
- Introduce fees for traffic-related pollution;
- Replace the existing lighting fixtures with more energy-efficient and environmentally friendly ones;
- Replace the existing electromagnetic control gear in lighting fixtures and install modern electronic mufflers, which opens the possibility of remote control of lighting fixtures.

The issue of climate change has become topical in the provisions of the SUP in terms of defining the purpose of building the so-called "blue" and "green" infrastructure.
Specific objectives in the field of energy management in the capital city match the previously defined ones and are related to the reduction of energy consumption and CO_2 emissions in

the building sector, traffic and street lighting, and increase of energy production from renewable sources.

1.3. Strategy / Action Plan coverage

The subject of analysis of the Strategy / Action Plan was the urban area of Podgorica, Tuzi and Golubovci.

For the purposes of SUP's development, for the organization of planning processes and implementation, and to monitor the implementation of the plan, the territory of the Capital City is divided into five planning areas:
I - Podgorica (area covered by the General Urban Plan of Podgorica, 1990),
II - The plains (Tuzi, Zeta),
III - Eastern hills (Malesija, Kuči),
IV - Northern hills (Ljevorječko area, Bratonožići, Piperi) and
V - Western hills (Lješanska Nahija).

The planning area of Podgorica, which includes urban area of Podgorica, without settlements Golubovci and Tuzi (area covered by the 1990 General Urban Plan of Podgorica), has been divided into 10 planning units / zones that represent functional and urban units.

Other planning areas of the capital city have been divided into 13 planning units / zones, which have specific natural and developmental characteristics and represent the hinterland catchment area of secondary municipal and significant local centres.

Taking into account this division of the SUP's area, the subject of analysis of this Strategy / Action Plan were planning units / zones from 1 to 12, that is, only the urban area of Podgorica, Tuzi and Golubovci (see map below).

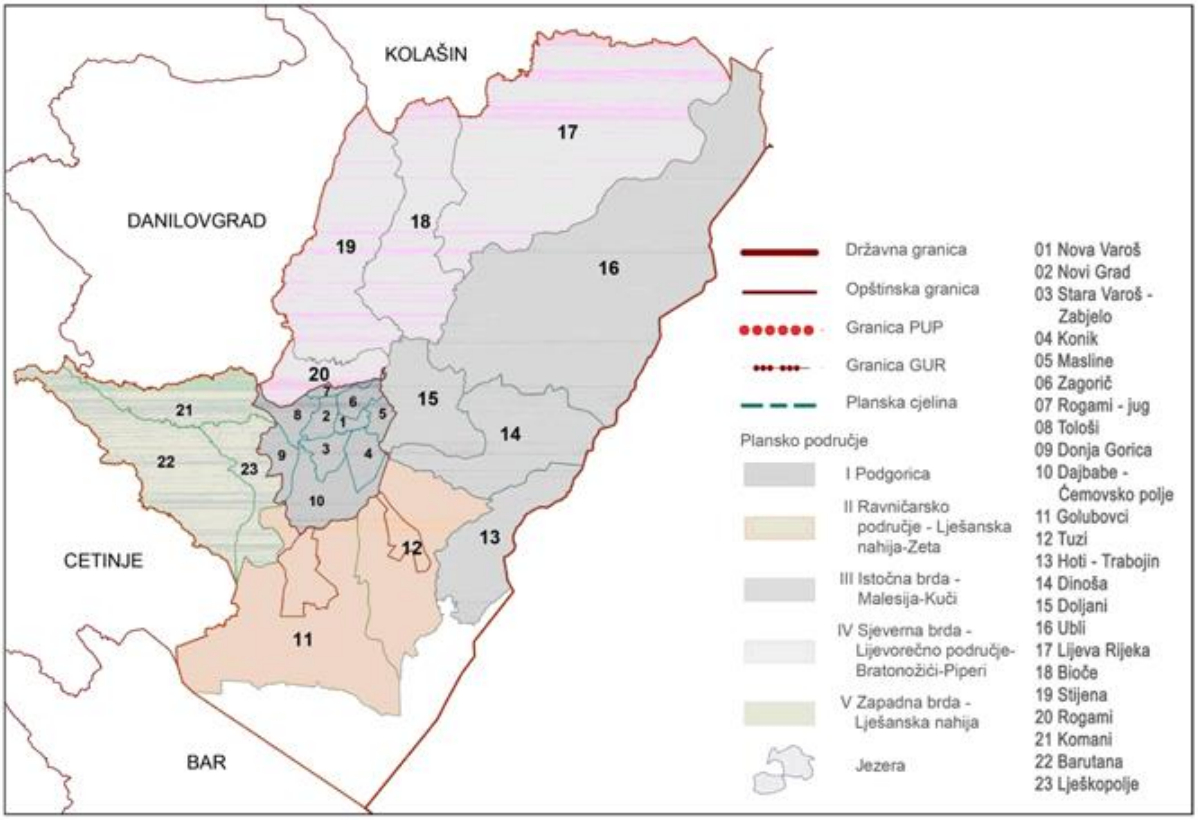


Figure 1: Planning units / zones of the Capital City of Podgorica

2. Methodological approach and process

The implementation of the Project assumed the activation of the human resources in the city administration institutions and services. In accordance to this, it was not expected that experts would independently deliver the whole process of drafting of Vulnerability study and Action plan with measures The focus was on a well-balanced cooperation between experts and the Working Group, where the members of Working Group, through expert elaboration of individual questions and their personal assessments, delivered certain outputs that finally resulted in documentation of results. To reach the defined goal, adequate supporting tools were used, based on the experience of other European cities with climate adaptation processes (e.g. from the EU project Future Cities). In this way, through the application of working steps, guidelines were given to members of the Working Group and other participants.

The consultants from "IU", through their participation in the Steering Group of the Project, were consulted about further steps and applied methodology. In that sense, they presented the method of using tools (filling of the defined tables) and they transferred knowledge and experience in this field, supporting the lead partner in the whole process. The working tools used by the Working Group, i.e. steps taken, are shown in the following Figure .

The technical and methodological terms are explained in the glossary.

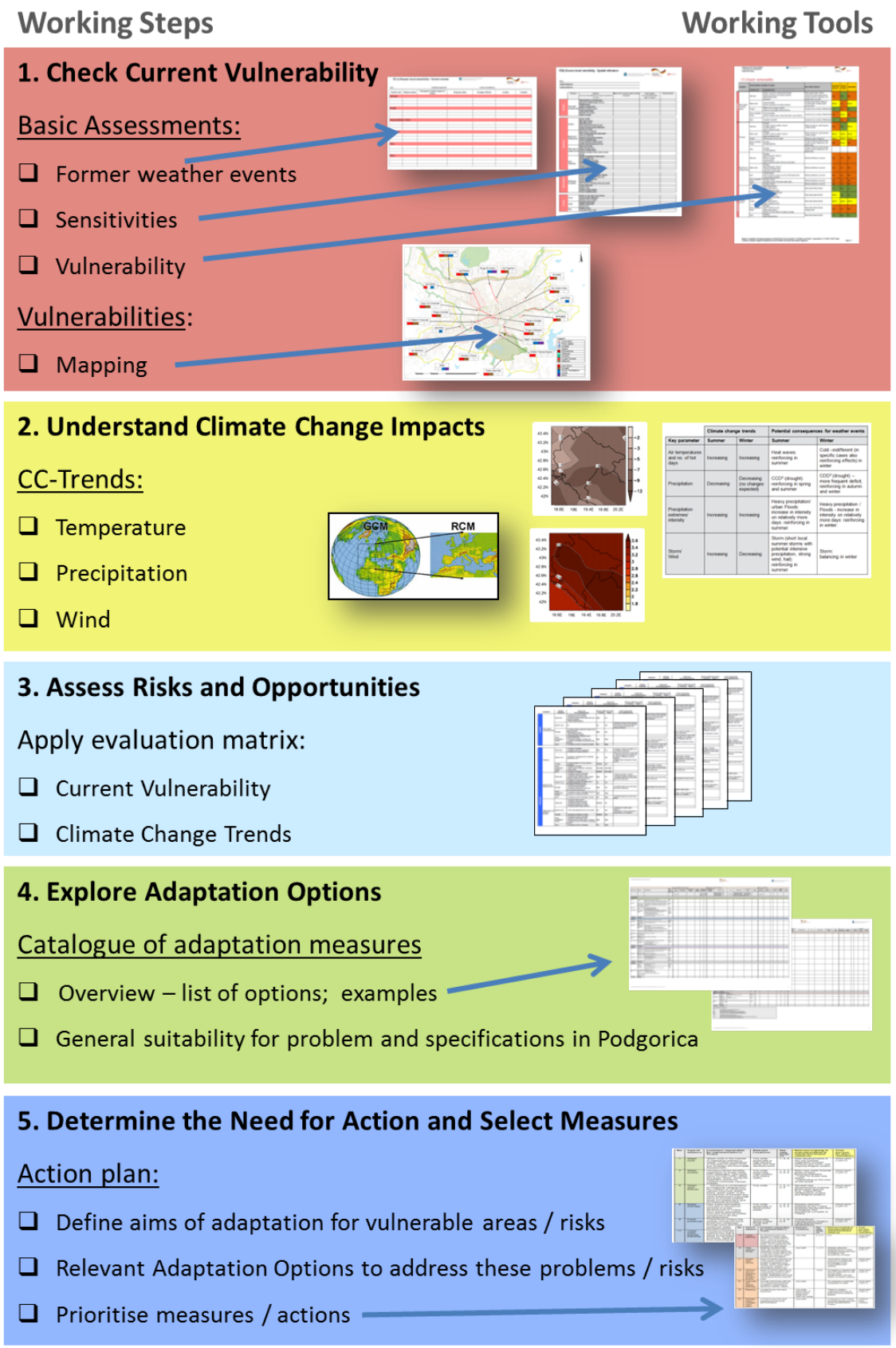


Figure 2: Working steps and tools

2.1. Working process and involved actors of the City

The project realization process assumed the interdisciplinary and interactive approach in order to achieve the satisfactory level of measure definition for adaptation to climate change. Therefore interdisciplinary Working Group (WG) has been formed consisting of different professional profiles from different relevant city institutions. The working process of the Working Group was carried out through meetings. The Steering Group (SG) meetings served to prepare and coordinate the working steps, define interim results, reach conclusions and thus reach the project objectives.

The Steering Group was part of the Working Group. Additional WG members were different administration representatives and additional project relevant stakeholders of the City of Podgorica. The institutions of the respective group members are listed in the following table.

Table 12: Group members – institutions represented

Group	Institutions represented by group members
SG	Lead Partner (Secretariat for Spatial Planning and Environmental Protection) Program Manager (GIZ) International Consultant (IU) Local expert (Sasa Karajovic, MonteCEP)
WG	Administrative representatives of Capital City of Podgorica: - Secretariat for Social Welfare - Secretariat for Entrepreneurship Development - Secretariat for Finance - Secretariat for Culture and Sport - City Municipalities Golubovci and Tuzi Representatives of companies and institutions of Capital City of Podgorica: - Housing Agency - Agency for Construction and Development of Podgorica - Protection and Rescue Office - Water Supply and Sewage Ltd - Sanitation Services Ltd - Greenery Ltd Relevant stakeholders from Podgorica: - Public Health Institute - Mirjana Ivanov (Hydrometeorology and Seismology Institute, Podgorica)

The list of all WG members can be found in Annex 6.

The interdisciplinary structure of the CCA Working Group forms the basis to continuously mainstream CCA issues.

On 30 January 2014, the first joint meeting of representatives of all the Project partners was held in Brussels to present the methods and goals of the Project, as well as the most important needs and expectations of cities.

In February and March 2014, consultants from the Company "Infrastruktur und Umwelt" reviewed the existing relevant documents. Based on the results of GIZ's Feasibility Study "Adaptation to Climate Change in Urban Areas of the Western Balkans" and other available materials, the research focused on:

- The legal and organizational framework
- Information on the impact of climate change, and
- Existing adaptation strategy at the city level.

After that the selected cities of Podgorica, Belgrade and Tirana were visited for meetings with various relevant representatives of city administration and other institutions, with respect to their role in the future process of the Project. Likewise, the actual communication enabled the collection of additional data to complement the research, compile the documents and prepare an "Inception Report".

In the period from 16 July 2014 to 8 April 2015, 3 meetings of the Steering Group, the Working Group and consultants from the company "Infrastruktur und Umwelt" were held in total. In addition, several meetings were held through online communication.

Also, there were 10 independent meetings of the Working Group, to elaborate the inputs obtained from consultants and outstanding issues related to certain stages in the Project.

On 25-26 February 2015, the Second Regional Meeting of the Project partners was held in Belgrade, during which the results of the previous work were presented, in addition to challenges and dilemmas, and suggestions were obtained on how to continue the Project and bring it successfully to the end.

The list of all meetings of SG and WG can be found in Annex 5.

2.2. Methodological approach - overview

The methodological approach of the Climate Change Adaptation project in Podgorica used the working steps of the Adaption Compass of the EU project “Future Cities” which were adjusted to the situation of Podgorica (see FC, 2013). The Future Cities Compass is a practical adaptation approach which was developed by a partnership of cities from different EU countries, and it is used in several countries (e.g. Germany, UK). Main advantages of this approach are a clear structure, available checklists to structure the working steps and the use of estimations and trends appropriate for the practical daily work. Furthermore, it offers a view to the city as a whole and the integration of different city departments. The approach consists of several working steps that are highly interlinked.

Both the Vulnerability Assessment (VA) and the Adaptation Action Plan are part of this process. The vulnerability assessment contains three working steps - check vulnerability, understand climate change impacts and assess risks and opportunities. The Adaption Action Plan is composed of two working steps - a general exploration of adaptation options and the specific determination of the need for action with the selection of adaptation measures for the city of Podgorica (see Figure).

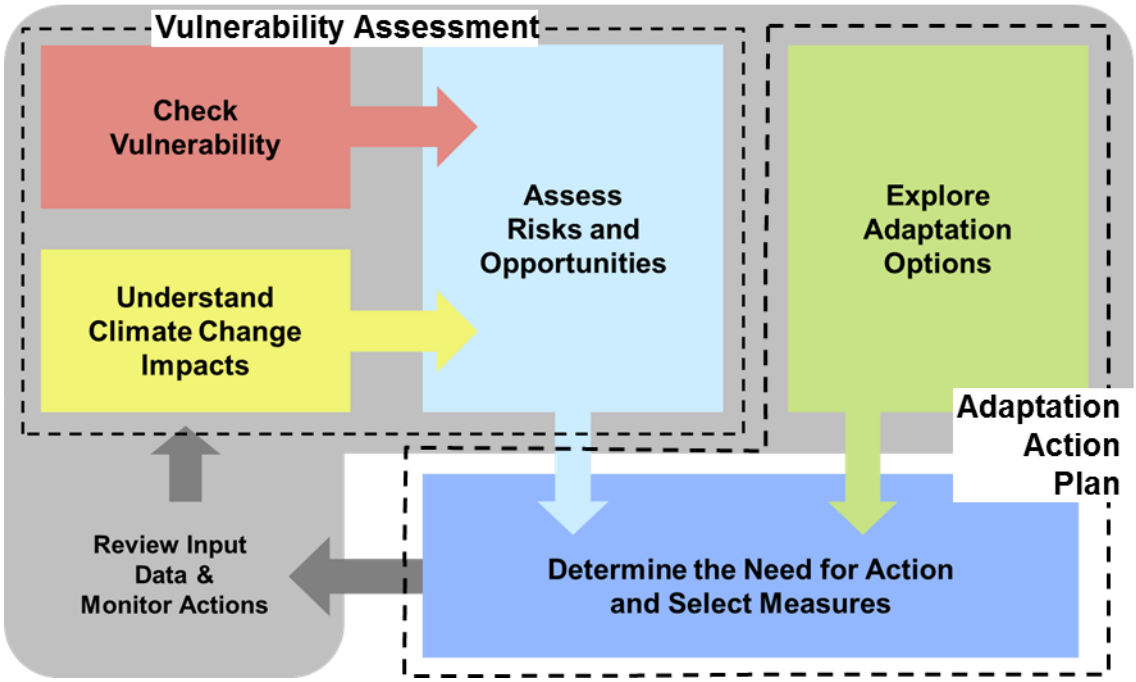


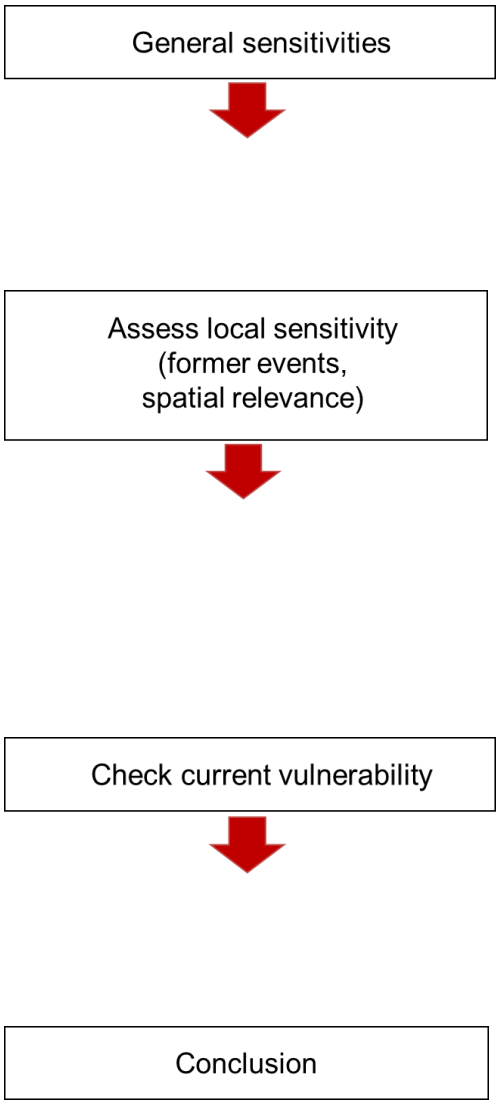
Figure 3: Overview of the methodological approach (FC, 2013)

The remaining step of this approach is a circulatory step that focuses on both reviewing input data and monitoring actions, see chapter 6.

2.3. Vulnerability Assessment

2.3.1. Check current vulnerability

The local physical features and socioeconomic conditions - called receptors (such as population or infrastructure) - were the starting point for the check of current vulnerability towards extreme weather events (like heat wave or heavy precipitation). The assessment of the current vulnerability of receptors included the following steps, see Figure.



General consideration of receptor sensitivities of Podgorica - get to know the receptors and corresponding sensitivities towards weather extremes.

Assess local sensitivities by taking into account former extreme weather events and identifying the respective spatial relevance. This required the WG to compile a list of former extreme events that affected the city of Podgorica and analyse which receptors were affected. In parallel, most affected receptors were identified and the location and spatial distribution of sensitive receptors defined.

The vulnerability check combined the assessed sensitivities and exposure of a receptor with the respective capacity to adapt on extreme weather events. The determination of the class of vulnerability (high, medium, low) of the investigated receptors based on an evaluation matrix, see Table 13.

The step comprised a summary of extreme weather events as well as most affected receptors in Podgorica.

Figure 4: Working steps - check of current vulnerability[1]

The tables “Former events” and “Current vulnerability” resulting from the described check can be found in Annexes 1 and 2:

- The table “Former events” lists extreme weather events (heat wave, extreme cold, drought, heavy precipitation/floods and storm) in the past (2003-2014), with

[1] Note: Explanation of technical/methodological terms can be found in the glossary.

corresponding consequences, responses taken, affected receptors and locations, see Annex 1.

- The table “Current vulnerability” lists the general sensitivity of the different receptors dependent on different types of extreme events and detailed information about whom or what is affected. In addition, the WG assessed the sensitivity and exposure as well as the capacity to adapt of the receptors and that became part of the table. Finally, the resulting classes of vulnerability are listed, see Annex 2. For the determination of the class of vulnerability the following matrix was used.

Table 13: Matrix to determine the class of vulnerability of receptors

		Capacity to adapt		
		Low	**Medium**	**High**
Sensitivity/ Exposure	**High**	High	High	Medium
	Medium	High / Medium	Medium	Medium / Low
	Low / No	Low	Low	Low

The classification of the specific capacity to adapt of a receptor built on the ability (financially, technologically or socially), willingness and preparedness to cope with weather and climate extremes. For example, in case of a high sensitivity and exposure combined with a low capacity to adapt – the class of vulnerability of a receptor would be “high”. In case of a high capacity to adapt – the class of vulnerability would be “medium”.

2.3.2. Understand Climate Change Impacts

The general definition of climate change is important to understand climate change impacts. The terms climate and weather describe two very separate circumstances. Climate is the average state of the atmosphere, whereas weather describes the current atmospheric conditions.

Weather can only be predicted for a short time period. Little differences in the starting conditions of meteorological parameters, e.g. the humidity level, can lead to very large differences in the results, even over a short period of time.

Climate on the contrary is described by statistic values, like means, variances, probabilities etc. of meteorological parameters for specific periods of time. For example, long-term in the context of climate change typically means a time span of at least 30 years.

Changes in mean values and extreme events are calculated by Climate models in order to deduce important trends in climate as the consequences of increased GHG concentration. The modelling results available on future climate are not the forecast but possible projections of a future climate situation (ranges and changes of mean values). Climate models that

simulate the whole climate on earth are called global climate models. They can deliver data on a horizontal resolution of about 200 x 200 km. Since for many analyses this resolution is not detailed enough, regional climate models have been developed. These regional models use a statistical or dynamic downscaling of the global climate model data and reach horizontal resolutions of 10 x10 km. When considering a city with small scale features and lots of influencing factors to the micro-climate, even regional climate models are not detailed enough. But as uncertainties increase with time and resolution, a further downscaling makes little sense.

The bases for all climate models are assumptions on future development of GHG emissions, demography, society, techniques, economy and ecology. These assumptions are described in scenarios. Most climate models use emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC).

Based on the available projections climate change trends for Podgorica were deduced. The used parameters were air temperature, precipitation and extreme events (heavy precipitation, consecutive dry days, heat wave intensity and duration, storm / wind). A distinction between trends for summer and winter was necessary as some trends and consequences might differ. Consequences of impacts of CC trends on relevant receptors of Podgorica can be:

- Reinforcing: The trends are intensifying the respective situation (e.g. it gets hotter in summer) and therefore the vulnerabilities identified will increase in future.
- Indifferent: No changes in the trends are expected; therefore the vulnerabilities identified will not increase in future.
- Balancing: The trends are balancing the respective situation (e.g. it gets warmer in winter and extreme cold becomes less probable) and therefore the vulnerabilities identified will decrease in future.

2.3.3. Assess Future Risks and Opportunities

Change of climate conditions might increase future risks but also might offer future opportunities. The assessment is built on the identified current vulnerability (see chapter 2.3.1) and the projected climate change impacts (see chapter 2.3.2).

The classes of current vulnerability of receptors in Podgorica were combined with the projected future climate change impacts. The following evaluation matrix was used:

Table 14: Evaluation matrix of future risks

		Climate change impact		
		balancing	indifferent	reinforcing
Current vulnerability	High	medium	high	very high
	Medium	low	medium	high
	Low / No	low	low	medium

The results are summarised in table “future risks and opportunities”, see annex 3. The table created a basis for deciding which issues should be considered first or looked into more detailed (identified very high and high risks).

Note: Concept of risk:

In this approach, "risk" is the combination of current vulnerability (high, medium, low) and the climate change impact (balancing, indifferent, reinforcing - as concluded from climate change trends). Risk is categorised by the severity of consequences in the classes very high, high, medium and low. Often, the term risk is defined as the combination of the probability of occurrence and the magnitude of the consequences or of the hazard. In the method used here, the probability of occurrence is not evaluated because the climate change impact is based on tendencies and qualitative descriptions. The uncertainties of climate change projections are, at least for some climate parameters, very high (uncertainties from scenarios, from models or sampling uncertainty).

Nevertheless, the results of climate projections can be valuable background information for regional and local adaptation decisions. The decisions though should always be taken on the basis of a variety of information, like vulnerability assessments and general spatial planning needs, development plans etc. Most adaptation options are not only beneficial for climate change adaptation but also for other sectors, e.g. economic growth. Even if climate change impacts do not occur as expected the measures are though beneficial and cost-effective.

2.4. Adaptation Action Plan

The development of an adaptation action plan within this project comprised two steps "Explore Adaptation Options" and "Determine the Need for Action and Select Measures", see Figure in Chapter 2.2.

Explore Adaptation Options: The Working Group identified adaptation options based on a general catalogue of structural and non-structural adaptation measures. The options included measures that are already taken into account in the city of Podgorica and additional potential measures to face future risks.

Table 15: Categories of adaptation (and mitigation) options

Structural measures	Green structures
	Water system
	Urban structure
	Building design
Non-structural measures (e.g. awareness raising, restrictions, etc.)	
Mitigation measures with a close link to adaptation (e.g. renewable energy measures)	

Determine the Need for Action and Select Measures: The determination and selection process comprised the specification and prioritization of measures based on specific criteria (suitable to refer to the results of the vulnerability assessment, i.e., most important future risks of specific vulnerable locations in Podgorica). After the prioritization of selected

measures, the action plan could be ranked according to the main criteria of the city of Podgorica.

Table 16: Prioritization of selected measures

Criteria	Rating	Explanation
Suitability for problem solving	**++** **+** **o** **-**	Significant reduction of risk Reduction of risk No impact expected Increases risks / negative impact
Additional benefits	**++** **+** **o**	Additional benefits for several other sectors / problems Some additional benefits can be noticed No additional benefits
Costs	**++** **+** **o** **-**	Very low direct and indirect costs Low direct and indirect costs Medium direct and indirect costs High direct and indirect costs, high maintenance
Complexity of measure	**++** **+** **o** **-**	Easy to implement; no legal / technical implications; short-term; high acceptance Little complexity; no legal implications; short/medium term; basic acceptance Medium complexity; legal implications, which can be overcome; medium-term, little acceptance High complexity; comprehensive legal and technical implications; long-term; no / little acceptance
Negative external effects	**+** **o** **-/--**	No negative external effects identified Identified, but can be mitigated Few / many external effects identified

3. Climate Change trends in Podgorica

3.1. Observed climate changes

The following information was gathered from the Initial Communication of Montenegro under the United Nations framework convention on climate change - provided by Mirjana Ivanov (Institute of Hydrometeorology and Seismology), (Ivanov, 2014):

Temperatures

In the analysed period from 1951 to 2010 in Podgorica the mean annual temperature shows a warming trend. The period from 2001 to 2010 was the warmest decade from the beginning of measurements (1949 for Podgorica). In this decade, the mean annual temperature was 1°C warmer than during the base period 1961 to 1990 (Ivanov, 2014). Analysis of temperature extremes shows their significant increase, which is graphically presented in Figure 1. It is important to note that the highest daily temperature in Montenegro was registered in Podgorica in August 2007, with the value of 44.8°C.

Table 17: Mean annual air temperature per decades and its change Δ (°C) in 2001-2010 in relation to the 1961-1990 climatological mean in Podgorica (Ivanov, 2014)

Base period	Decade						
1961-1990	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	Δ(°C)
15.3	15.5	15.4	15.0	15.4	15.8	16.3	+1.0

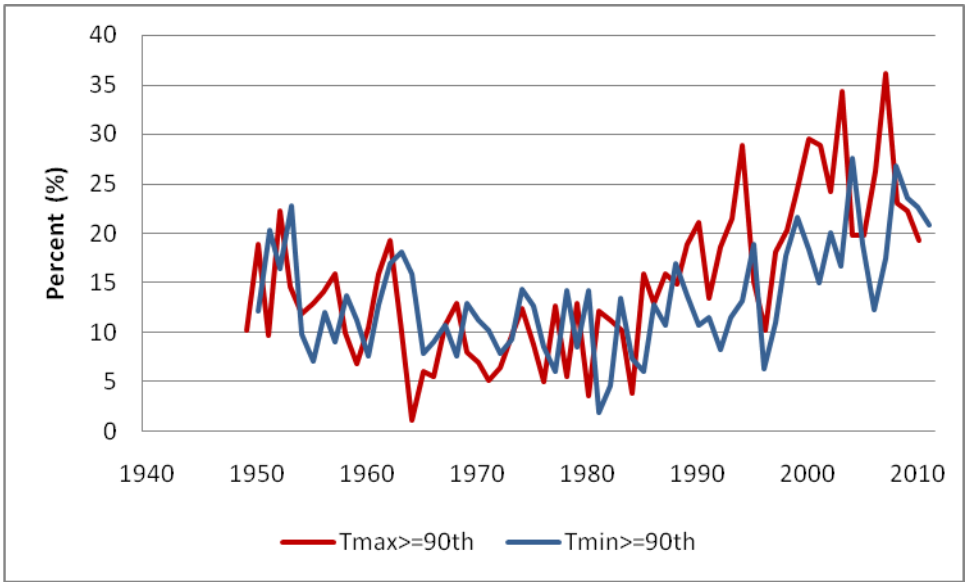


Figure 5: Percentage of time when Tmax and Tmin was over 90th percentile in Podgorica (Ivanov, 2014)

Precipitation

In the period analysed (1951 to 2010), no significant change of mean annual precipitation was observed. Seasonal changes in precipitation show that it increases within normal threshold in autumn and decreases within normal threshold in spring, summer and winter. There was a statistically significant increase for the month of September in the Capital of Podgorica (Ivanov, 2014). In general, the changes of annual precipitation show that there is a change in regime of precipitation which becomes more extreme in its character. The decade 2001-2010 was the record decade according to the average annual precipitation amount after 20 years of consecutive slight decrease. The year 2010 was the record year in annual amount of precipitation, which coincides with strongly developed La Nina (Ivanov, 2015).

Table 18: Average annual precipitation (mm) per decade and its change Δ (mm) in 2001-2010 in relation to the 1961-1990 climatological mean (Ivanov, 2015)

Base period	Decade						
1961-1990	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	Δ(mm)
1657.9	1632.1	1756.7	1695.2	1521.7	1593.7	1781.6	+123.7

Table 19: Average intensity of precipitation [mm] in the days with heavy rainfall (> 20 mm) (Ivanov, 2015)

Base period	Decade					
1961-1990	1951-60	1961-70	1971-80	1981-90	1991-2000	2001-10
39.8	34.6	38.1	39.7	41.6	40.1	50.0

3.2. Climate Change Scenarios

In a number of the following conclusions, climate change projections are presented as developed for the Initial and 2nd Communication of Montenegro under the United Nations Framework Convention on Climate Change[2] using regional model EBU-POM for the time periods 2001-2030 and 2071-2100 in comparison to the reference period 1961-1990. The modelling uses the A1B ("medium") and A2 ("strong") scenarios to project the changes in temperature and precipitation as well as the changes in extreme climate events.

[2]Initial Communication of Montenegro under the United Nations Framework Convention on Climate Change: mean annual and seasonal temperature; 2nd Communication of Montenegro under the United Nations Framework Convention on Climate Change: extreme events

Temperatures

The results of the modelling indicate a further increase in air temperature (with relatively higher increase in summer and spring) and number and duration of extreme events per year, see table below.

Table 20: Projected air temperature changes for Podgorica area and changes of extreme events expressed by indexes for hot days and heat waves (Djurdjevic, 2014)

		Future time period compared to reference period 1961-1990		
		A1B scenario		A2 scenario
		2001-2030	2071-2100	2071-2100
Mean annual temperature		+ 0.9°C	+ 2.6°C	+3.5°C
Mean seasonal temperature	winter	+ 0.7°C	+ 2.1°C	+ 3.0°C
	spring	+ 1.0°C	+ 2.6°C	+ 3.6°C
	summer	+ 1.2°C	+ 3.4°C	+ 4.6°C
	autumn	+ 0.6°C	+2.1°C	+2.9°C
Mean annual no. of hot days (> 90th percentile daily max. T)		Total: 79 d + 44 d	Total: 174 d + 139 d	Total: 212 d + 177 d
Mean duration of heat waves		Total: 9.6 d + 1.8 d	Total: 12 d + 4.2 d	Total: 14.6 d + 6.8 d
Mean annual no. of heat waves[3]		Total: 4.2 + 3.2	Total: 10.8 + 9.8	Total: 11.7 + 10.7

[3] Heat wave duration index defined as: over 90th percentile max daily temperature lasting at least 6 consecutive days

Precipitation

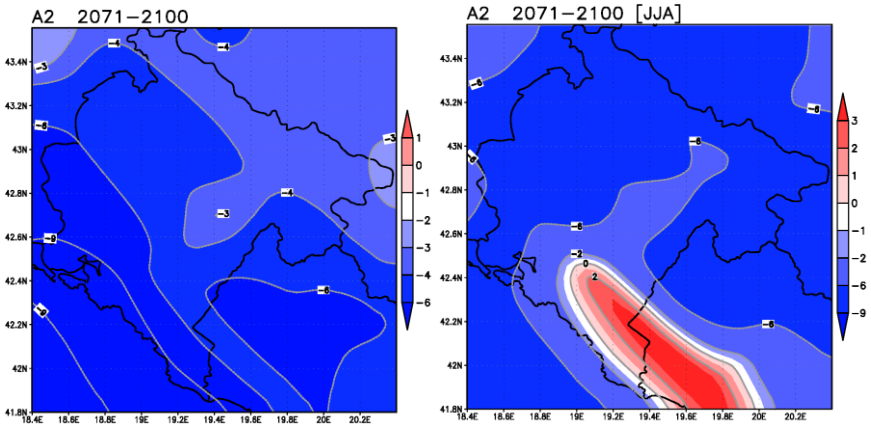
The results of the modelling indicate a decrease in mean annual precipitation. The future decrease is most noticeable in autumn. For the winter season there is a big uncertainty for the amount of deficit in precipitation comparing the two scenarios as the interval of its possible realisation is between -4.4% and -34.4%. Considering extreme climate events, the projection of the mean number of days with heavy precipitation over 20 mm per day shows a decrease in both scenarios with slightly positive change of the mean intensity on these days. The mean number of consecutive dry days with precipitation less than 1 mm is expected to increase.

Table 21: Projected changes for Podgorica area for precipitation and its extremes (Djurdjevic, 2014)

		Future time period compared to reference period 1961-1990		
		A1B scenario		A2 scenario
		2001-2030	2071-2100	2071-2100
Mean annual precipitation		- 9.6 %	-31.2 %	-15.5 %
Mean seasonal precipitation	winter	- 8.7 %	-34.2 %	-4.4 %
	spring	-5.3 %	-14.3 %	-22.1 %
	summer	+2.8 %	-25.3 %	-10.2 %
	autumn	-17.2 %	-41.0 %	-27.2 %
Mean no. of days with heavy precipitation (> 20mm per year)		Total: 22.9 days/year -3.5 day/year (-13 %)	Total: 17.8 days/year -8.6 day/year (-33 %)	Total: 21.1 days/year -5.3 day/year (-20 %)
Mean intensity of precipitation in the days with heavy precipitation		Total: 45.9 mm/day + 3.6 mm/day (7 %)	Total: 42.3 mm/day 0 mm/day (0 %)	Total: 47 mm/day + 4.7 mm/day (9 %)
Mean consecutive no. of dry days (precipitation < 1 mm)		Total: 34.9 days + 2 days (5 %)	Total: 35.8 days + 2.9 days (7 %)	Total: 37.8 days + 4.8 days (11 %)

Wind extreme – maximum speed

The results of the modelling indicate a slight decrease of mean annual maximum speed for the both scenarios (A1B and A2) and both time intervals. The possible decrease is around -5% with respect to the climatological mean 1961-1990. Furthermore, intensive extreme events in the summer followed by intensive precipitation, hail, and strong wind are expected to increase.



a) b)

Figure 6: **Example: scenario A2, period 2071-2100 (Djurdjevic, 2014)**
a) Projected change in mean annual maximum wind speed (%) with respect to the 1961-1990 base period
b) Projected changes in mean summer maximum wind speed (%) with respect to the 1961-1990 base period

3.3. Conclusions from climate change trends to be considered for the future risks of vulnerable receptors

From the climate change trends like “increasing air temperature” or “decreasing precipitation”, conclusions were drawn to get an overview of the future risks:

- Reinforcing: The trends are intensifying the respective situation (e.g. it gets hotter in summer) and therefore the current vulnerabilities will increase in future.
- Indifferent: No changes in the trends are expected; therefore the current vulnerabilities will not increase in future due to climate change.
- Balancing: The trends are balancing the respective situation (e.g. it gets warmer in winter) and therefore the current vulnerabilities could decrease in future.

Concerning heat, in spring and summer time, the observed impacts and vulnerabilities will be reinforced due to expected increase in air temperatures and number of hot days. Heat waves are expected to last longer and to occur more often.

The average air temperatures in winter are expected to increase. Extreme cold temperatures are less probable. For specific vulnerabilities milder winters could lead to reinforcing effects (e.g. vector borne diseases).

Concerning precipitation, the expected decreasing trend in summer as well as higher air temperatures and therefore higher evaporation rates could lead to longer and more frequent droughts. This should also be considered for autumn. During winter the possible range of the precipitation deficit is big, therefore it is recommended to consider further analysis and to develop flexible measures to cope with a broad span of possible impacts.

The precipitation regime is expected to become more extreme with higher intensities as the number of days with heavy precipitation is expected to decrease. Therefore, current vulnerabilities will be reinforced in summer and in winter.

Regarding storm and strong winds, increasing intensive extreme events in summer (short local summer storms with e.g. intensive precipitation, hail, strong wind) will lead to reinforcing effects. During other seasons, decreasing wind speeds can lead to balancing effects and could mitigate current vulnerabilities.

Table 22: Conclusions for potential climate change impacts for Podgorica area for future period

	Climate change trends		Potential consequences for weather events	
Key parameter	**Summer**	**Winter**	**Summer**	**Winter**
Air temperatures and no. of hot days	Increasing	Increasing	Heat waves: reinforcing in summer	Cold – indifferent (in specific extreme cases potential reinforcing effects)
Precipitation	Decreasing	Decreasing	CDD[4] (drought): reinforcing in spring and summer	CDD[4] (drought) – more frequent deficit, reinforcing in autumn and winter
Precipitation extremes/ intensity	Increasing	Increasing	Heavy precipitation/ urban Floods: increase in intensity: reinforcing in summer	Heavy precipitation / floods – increase in intensity: reinforcing in winter
Storm/ Wind	Increasing	Decreasing	Storm (short local summer storms with potential intensive precipitation, strong wind, hail): reinforcing in summer	Storm: balancing in winter

[4] Consecutive number of Dry Days (CDD): average no. of consecutive days with precipitation < 1 mm

4. Results of the vulnerability assessment of Podgorica

The results of the VA of Podgorica described in chapter 2.3 are explained within the following sub-chapters. Based on the current vulnerabilities identified (see chapter 4.2) and the expected impacts of climate change trends (see chapter 3.3) both future risks and opportunities are evaluated (see chapter 4.3).

4.1. Extreme weather events in the past

As described in chapter 2.3.1, the check of current vulnerability comprised several steps.

The assessment of local sensitivities included a compilation of former events in order to identify the respective spatial relevance. Therefore the WG compiled a list of former extreme weather events that affected the city of Podgorica.

Generally, extreme weather events were shown (heat waves, droughts, heavy rains, storms...) in the past (2003-2014), including the accompanying consequences, affected receptors and locations.

Detailed results of the analysis of past events for the territory of Podgorica are presented in Annex 1.

HEAT WAVES

Heat waves in Podgorica were recorded on several occasions during 2003, 2004, 2005, 2006, 2007, 2011, 2012, 2013 and 2014.

During these periods, several records in maximum daily temperature at the national level were recorded (42.2°C - August 2003; 44.8°C - August 2007. and 44°C - August 2012).

Also, during 2011 and 2012 the number of tropical days and tropical nights was higher than the climatological normal.

Heat waves have caused increased heat stress in the population, with a particularly negative impact on the health of vulnerable groups (elderly, children, people with cardiovascular and heart diseases and mentally ill). In addition, a decrease in labour productivity, especially in agriculture, infrastructure and construction, reduction of other economic activities (trade, utilities), and increased consumption of electricity and water consumption have been recorded.

Most affected were urban areas in Podgorica, Tuzi and Golubovci, as well as city parks (Njegošev, Karađorđev, Kraljev, Centralni, Ivanov i Kruševac), forest parks, the block and linear greenery.

DROUGHT

Period between 01/06 to 10/09/2003 was marked by drought, which has developed into an agricultural drought. This has contributed to a *very warm* spring and *extremely hot* summer.

After a few years, a new drought occurred and agricultural drought developed into hydrological drought. In the period from 01/06 to 19/10/2007, the maximum number of consecutive days without rainfall was 56, which is the third highest recorded number with the same values as in 1988 and 1989. That year the spring, summer and winter were *extremely warm*.

Extremely dry conditions were recorded during the whole year 2011. Drought has developed to hydrological drought. Mean air temperature was above the average for the most part of the year. November of 2011 was the driest month observed since 1970. This year was characterised by a *very warm* spring, the *extremely hot* summer and autumn, and a winter in the *warm* category.

During the summer season of 2012, very dry conditions dominated. Due to the hydrological drought during the previous year 2011, favourable conditions for large-scale forest fires were created. Spring was in the category of *very warm*, and summer, autumn and winter were *extremely hot.*

Droughts caused limitations in the availability of drinking water, whereas agricultural production in suburban areas suffered extensive damage. The water level in the rivers reached the minimum. Smaller streams dried up. Damage to biodiversity was reported, there was a drying of vegetation that is less resistant to high temperatures and has a greater need for water. As a side-effect of drought, hot asphalt surfaces further increased air temperature.

Particularly affected were the green and park areas in the city and the gardens and yards in the suburbs. The operation of the plant for waste water treatment was slowed down.

FIRES

As a consequence of the above mentioned heat waves and dry periods in Podgorica, several large-scale fires were recorded in the following periods: 04/08/2007, 24/08/2011, 16/07/2012, 24/07/2012 and 31/07/2013.

During these fires, a large area under forests was destroyed, increased occurrence of smoke and smog in the territory of Podgorica was recorded and a great material damage was created.

Particularly affected were the forest park across from KAP, Gorica, Ćemovsko field and Golubovci. In the refugee / Roma settlement Konik – Camp, 29 barracks burned down and 150 families with a total of 800 persons were left without accommodation.

EXTREME RAINFALL/ FLOODS

From December 2009 to January 2010, there was a series of intense cyclonic activities followed by heavy rainfall. The level of water level of the river Moraca was 702 cm, or 44% of the maximum water level. Heavy rainfall led to an increase in the water level of Skadar Lake and high groundwater levels and caused flooding in the villages of Gostilj, Kurilo, Ponari, Bistrica, Bijelo Polje and Vranjina. The maximum water level wave measured was recorded on 12/01/2010 and amounted to 495 cm, which is the highest since 1963. Heavy rainfall led to the flooding of river Rujela out of its river bed.

During the three days, from 30/11 to 01/12/2010, heavy rainfall with over 100 l/m² was recorded. It was the largest flood ever recorded, having in mind that the water level recorded on measuring station Plavnica surpassed by 38 cm the level of Skadar Lake in January 1963, when the water level reached a maximum recorded water level of 530 cm. The rivers Rujela, Cijevna and Skadar Lake flooded out of their river beds. The strong cyclonic activity continued followed by strong south wind and high air temperature, which caused heavy rainfall (over 146 l/m²). The maximum recorded water level of Skadar Lake during this new flood wave was recorded on 04/12/2010 on the Plavnica station and amounted to 588 cm (the highest ever measured value).

During 2012, heavy rainfalls were recorded on two occasions: on 27/08 and 28/08 (heavy rains due to strong cyclone activity from the Alps; 93 mm of rain) and on 29/11/2012 (for little more than 24 hours, there was 157 l/m2, which is 66% of the average rainfall for November).

The second half of March and early April of 2013 again were characterized by heavy rains - the rain of high intensity followed by strong south wind. On 05/04/2013, the water level of 445 cm was measured.

On 21/01/2014, due to heavy rainfall the river Rujela flooded out of its river bed again.

SNOWFALL

Snow is rare in Podgorica, and thus it represents extreme weather event. Snow was recorded in January 2005, and 2012 was particularly snowy, with several snow falls: 01-08/02 (snowfall with strong north-eastern wind and frigid temperatures, the height of snow cover reached over 50 cm), 11/02-24/02 (up to 57 cm of total snow cover) and 11/12/2012 (15 cm of snow cover).

Snowfall was also recorded from 02 to 04/02/2014 (up to 32 cm of snow cover).

***

During the recorded periods of extreme rainfall and snowfall, numerous residential and commercial buildings were flooded and certain streets could not be used. The road and air traffic was interrupted. In extreme cases schools and kindergartens were also closed, and the state of emergency was declared (evacuation and taking care of the population and material goods). There were power outages in some parts of the city. An increase of water turbidity and discoloration of water was registered due to leaching and drinking water from individual wells was not in use. There was a discharge of septic tanks and large amount of waste was piled up. The operation of the waste water treatment plant was especially difficult.

Due to heavy rains, some parts of Podgorica were especially threatened (underpass on Tuški Put, streets: Vojislavljevića, 27.marta, Kralja Nikole, Oktobarske Revolucije, Bulevar Revolucije and underpass on Zlatica, Savin Potok riverbed), Municipality of Golubovci (Gostilj, Berislavci, Bijelo Polje, Bistrice, Kurilo, Vranjina, Ponari, Šušunja, Goričani, Mojanovići Golubovci, Mataguži) and Tuzi (urban part of Tuzi and surrounding villages of Podhum, Vranj, Vladne, Kodrabudan, Vuksanlekići, Tojeć and Omerbožovići in Dinoša area.

STORMS

Podgorica area was several times affected by storms, as follows: February 2009 (NE wind strikes of 50 km/h), 15/05/2010, 09/06/2010 (the amount of precipitation was 21.5 l/m2 with a blast of wind of 12.8 m/s from east-southeast and the occurrence of hail), 05/10/2010 and 12/07/2012. Extreme event was snow blizzard on 11/12/2012 (not typical for Podgorica, 20 cm of snow was measured, very strong gusts of wind of 16.9 m/s).

Finally, there was a tornado on 30/05/2013.

HAIL

Larger hail precipitation was recorded on: 09/06/2011, 26/05/2013, 19/06/2014 and 08/22/2014.

***

During the storms (with or without hail and snow), large material damage was inflicted to agricultural producers because the crops were destroyed. Also, the mechanical and physiological damage to plants was recorded, the occurrence of plant diseases and pests followed. There was also damage to buildings and vehicles, as well as

the electricity network and hydro systems. The main receptors were: crops and greenhouses in the suburbs (Tološi, Tuzi and Golubovci), parks and green spaces in the city, especially buildings with sloping roofs and infrastructure facilities.

From all this we can conclude that the extreme weather events often hit the territory of Podgorica and caused serious consequences.

Heat waves have had serious effects on the urban core, due to less vegetation, large percentage of the surface covered with asphalt and concrete, and due to the limited air movement. Also, the intensity of rainfall and the occurrence of floods are increasing. The most affected parts were the areas near Lake Skadar and small water streams in the territory of the city municipalities of Tuzi and Golubovci and in the city as well.

4.2. Current vulnerability

The current vulnerabilities, as a term, mean a result of the sensitivities and exposure of the receptors combined with the respective capacity to adapt to extreme weather events, as assessed by the WG for these particular needs.
The determination of the vulnerability class (high, medium, low) of the investigated receptors is based on the matrix in Table 3 (see chapter 2.3.1).
The whole list of receptors determined - sensitivity/exposure, capacity to adapt and resulting class of vulnerability dependent on different extreme events – can be found in Annex 2.
An overview of identified classes of current vulnerability regarding extreme weather events is illustrated in the following tables.

Table 12: Evaluation of vulnerability classes for population

Population	Heat wave	Extreme cold	Drought	Heavy precipitation/ Floods	Storm
Public health/ vulnerable groups	High	Medium	Low	High	Low
Social infrastructure	High	High (Roma)	High	High	High (Roma)

It is noticeable that particularly vulnerable groups (young and old, sick, workers who work outdoors...), as well as the majority of socially vulnerable groups (Roma, displaced persons...), have a high vulnerability to heat waves (especially in city centre) and heavy precipitation (accompanied by floods).

Table 13: Evaluation of vulnerability classes for infrastructure

Infrastructure	Heat wave	Extreme cold	Drought	Heavy precipitation/ Floods	Storm
Transport	Medium	Medium	Medium	High	-
Electricity services	High	High	High	High	High
Sanitation services	Low	Low	Medium	High	low
Water supply services	Low	Low	Low	High (Mareza)	Low

Electricity distribution system is very vulnerable under conditions of all extreme weather events, and so are social infrastructure facilities (e.g. high consumption during heat waves and cold periods cause frequent breakdowns).

Water supply systems and waste water channelling systems are particularly vulnerable in the case of heavy rainfall, when their plants operate with difficulties or are out of operation. The same situation is valid for transport, which has interruptions of regular functioning in the case of torrential rains and floods.

- Water supply: delivery of potable water to arid areas
- Heavy precipitation: problems with water supply from Mareza spring; insufficient capacity of sewage system and WWTP
- Flooded underpass at Tuški road
- Overflow of Rujela (Tuzi) and Cijevna riverbanks
- Lake Skadar (Golubovci) flood along the coast

Table 14: Evaluation of vulnerability classes for built environment

Built environment	Heat wave	Extreme cold	Drought	Heavy precipitation Floods	Storm
Building stock and materials	High	Low	Medium	Medium	High

The technical and urban infrastructure also shows high vulnerability in times of extreme temperatures and stormy weather – damaged roofs and flooded basements due to storms and floods, damaged roads…

Table 15: Evaluation of vulnerability classes for economy

Economy	Heat wave	Extreme cold	Drought	Heavy precipitation Floods	Storm
Tourism	Medium	Medium	-	Medium	Medium
Industry	Not existent				
Retail / SME	Low	Medium	-	Medium	Medium

No high vulnerability identified, due to high adaptive capacity of tourism and retail.

Table 16: Evaluation of vulnerability classes for natural resources

Natural resources	Heat wave	Extreme cold	Drought	Heavy precipitation Floods	Storm
Linear greenery	Medium	High (snow)	Medium	-	High
Ivanov Park, block greenery	High	High (snow)	High	-	Medium
Park forests	High	High (snow)	High	-	High
Water resources and quality	High	-	High	High	-
Air quality	-	-	High	-	-
Agriculture	High	High	High	High	High

City parks, block and linear greenery and park forests are extremely vulnerable in the event of heat waves, droughts, snowfalls, hail and storms. Air and water resources' quality are highly vulnerable due to heat waves and drought. Due to undeveloped/insufficient irrigation system, suburban greenery and park forests are threatened by fires, resulting in smog.

Agricultural production (especially in the peripheral parts of the urban area of Podgorica, Tuzi and Golubovci, as well as outside the project area) is highly vulnerable under conditions of all extreme weather events (heat waves, droughts, heavy rainfall accompanied by floods, hail and storm). Hail and drought result in decreasing crop and change in growth cycle.

Heat waves and drought in the summer, as well as heavy precipitation, are the most dominant weather events that cause problems in Podgorica.

Most affected receptors and exemplary locations, for which high vulnerabilities were identified, are shown in the following vulnerability map.

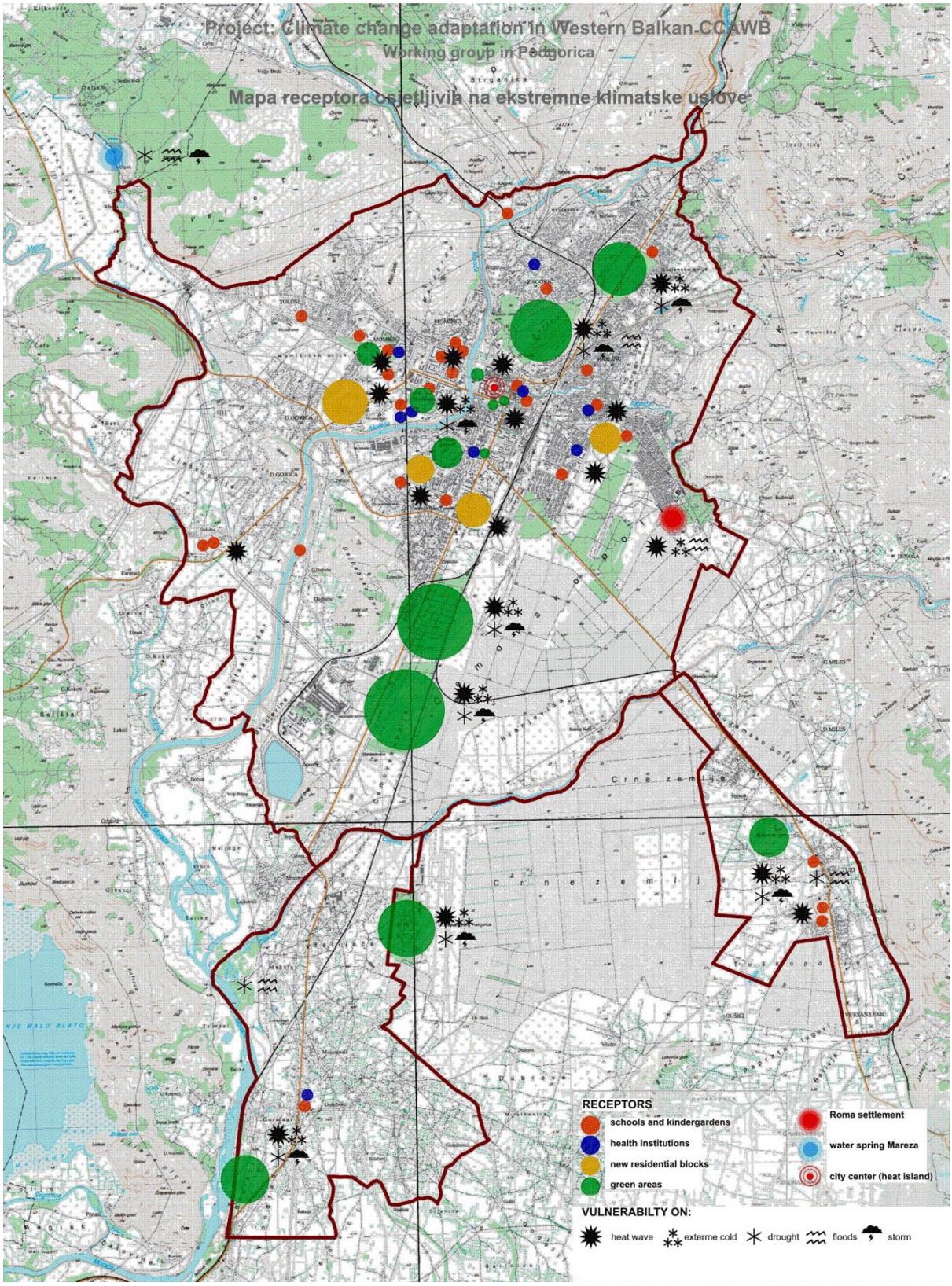


Figure 7: Potential vulnerable areas and structures
(Note: the size of the circle is proportionate to size/surface of receptor)

Source: CCA Working group: City of Podgorica / GIZ / INFRASTRUKTUR & UMWELT, 2015

4.3. Assessed future risks and opportunities

The assessment of future risks and opportunities builds on the identified class of current vulnerability of receptors and the impact of climate change trends (reinforcing, indifferent or balancing effects, see chapter 2.3.2).

The evaluated potential future risks and opportunities for the considered receptors are listed in Annex 3. In the following text, those future risks that are classified “very high” and “high” are explained and specified depending on the respective CC impact (air temperatures/ number of hot days, precipitation, heavy precipitation/ number of days with heavy precipitation as well as storm/ wind).

Expected future risks

It is known that heat waves in summer are associated with increased mortality in the population, while the relation of mortality in the winter period with climate change is more difficult to identify. The main causes of mortality in the winter period are diseases of the cardiovascular, cerebrovascular, circulatory and respiratory systems, and older adults are increasingly subject to these diseases. Increased temperatures during winter period will lead to a reduction of illness and mortality, particularly in patients with chronic illnesses on one hand, while on the other hand, the increase in average temperatures favour the spread of diseases transmitted through food and water, as well as the propagation of disease, such as rodents, ticks, mosquitoes, etc.

Social infrastructure facilities (e.g. hospitals, schools, kindergartens...) will have a greater need for cooling systems during the summer.

All kinds of transport may be affected due to heavy precipitation (rain, snow, hail...) throughout the year.

Due to the extreme weather conditions, year round, damage to the electricity network is possible, and due to extremely high or low temperatures problems in distribution are possible due to the increase in demand. All this will cause higher maintenance costs.

Due to the elevated temperatures during the summer greater need for cooling will exist and therefore a higher consumption of electricity in all other facilities (residential, commercial, production ...). In the city centre, the increase of the heat island effect it is possible, with the risk of overheating. Damages to the asphalt are also possible.

As a result of intense rainfall throughout a year, damage of roofs or flooding of the basements and cellars are possible, causing higher maintenance costs.

Extreme weather situations (heavy precipitation, storm ...) can lead to problems in the water and electricity supply including the problems with cooling. Problems due to heavy rainfall during the summer and during the winter can occur for the main water source and wastewater treatment plant.

Increased damage to equipment is possible, as well as loss of continuity of work - especially outdoors during the hot summer days. All this may lead to changes in lifestyle and habits of citizens.

Bad weather and extreme temperatures year round may increase the damage to public greenery and supporting infrastructure, which would lead to an increase in maintenance costs (watering and nourishment, intensive measures of nurturing). As a result of heat waves and dry periods, the risk of fires is increased.

Extreme drought periods can cause a lower level of groundwater recharge, increased evaporation and low water flow, which leads to a decrease of water resources. Such conditions favour the spread of algae and bacteria, which can lead to a reduction in water quality.

Due to the prolonged drought periods and heat waves year round, the increase in the level of smog is possible as well as a lower air quality.

Heavy rainfall with floods, year round, and extreme high and low temperatures, lead to changes in the growth cycle of certain plant species, increase the level of infestation and damage by pests and to the loss of or reduction in yields.

Drought periods year round include an increased need for watering as well as the risks of fires.

Extreme weather situations can lead to increased damage and dying of trees. Also, changes in the growth cycle are possible as well as the reduction in the number of species, loss of species susceptible to drought. The risk of forest fires is also increased.

Climate change may cause: the loss of certain species and the emergence of new, invasive ones, reduction of the species diversity, increased loss of habitat, as well as damages to the existing habitats or ecosystems.

High future risks regarding cold/extreme cold:

- Electricity and heating services: increasing number of damages due to increasing freeze
- Social infrastructure: more patients in hospitals; higher maintenance costs, e.g. for heating
- Green spaces: snowfall
- Agriculture: increasing damages and changes in the growth cycle due to the late spring or early autumn frosts

Expected opportunities due to climate change

Some new opportunities may occur as a result of climate change.

Higher temperatures in the winter will result in the reduction of illnesses and deaths, especially for chronic patients, on one hand, while on the other hand, increased average temperatures will create good conditions for the spreading of diseases transmitted via food and water. This will cause a reduced number of patients in health care facilities, and the stay in health care facilities will be easier and with easier maintenance.

More favourable weather conditions will lead to changes in the behaviour pattern, for example, more people would use a bike. In addition, milder winters may cause fewer traffic problems due to less snowfall and fewer freezing days.

More balanced temperatures during a year will lead to changes in level of burdening and demand in the electrical power system. Due to fewer cloudy days, there will be increased capacity for using solar energy.

Due to the trend of rising temperatures and changes in humidity, less damage to buildings and thus lower cost of their maintenance is expected. The increase in temperature and drought periods during the fall and winter will extend the construction season.

Expected climate change may lead to altered tourist season, as well as new tourism products – e.g. multiple outdoor activities for tourists.

Due to weather changes, we can expect the introduction of split shift working hours as well as changes in shopping habits – e.g. increased number of people using local shops. Also an interest in trading in the open can increase, which would open new market opportunities. This leads to the adaptation of products and services to climate change, and the creation of new products in response to changed market.

Reduction of the number of frosty and icy days can reduce the damage to agricultural crops and green areas. Better conditions for individual species or habitat restoration (e.g. in flooded areas) will be created.

5. Adaptation Action Plan

5.1. Adaptation objectives in Podgorica

Climate change adaptation is of key importance for reducing the risks and damage from the current and future impacts of extreme weather events, with efficient spending of resources, but also using the potential positive effects arising therefrom.

The adaptation component provides for efficient measures and reactions to climate change impacts, based on internationally accepted principles of sustainable development, which were accepted by Podgorica as its concept. Therefore, the endeavour to set as an objective to improve the existing and create new mechanisms for disaster risk reduction and to integrate climate change issues into all areas of local community development stems straight from the given concept.

Climate change adaptation demands an adequate approach to the management of natural and man-made values by recognizing the activities that should be undertaken in order to achieve the set objectives of reducing the impacts and consequences of extreme weather events.

> **Overall objective 1:** Management of natural and anthropogenic systems needs to be adjusted to the specificities of the Capital City as an urban area, while respecting the specific character of capacities themselves, as well as of the size and nature of the recorded problem.

Specificities of areas affected by climate change are a special challenge, considering their physical, geographical and socio-economic characteristics. Podgorica is an example of the area which includes all development sectors (industry, agriculture, tourism, etc.), but also the characteristics inherent to urban areas, and which concern the care of quality citizens' existence in terms of: water supply of households, provision of health care services, adequate spatial planning, maintenance of appropriate urban green areas, ecosystems and biodiversity.

Development and implementation of management plans often remains problematic due to poor cooperation between different sectors. Therefore, the process of developing the Climate Adaptation Action Plan included multiple sectors (such as maintenance services, urban planning, industry, agriculture and rural development), so the biggest challenge for adaptation management is exactly inter-sectoral cooperation. In support of this, one can certainly use the argument which regards the economic categories, as the said is considered as a prerequisite for the reduction of financial expenditures.

The action also depends on the nature of identified individual objectives. The implementation of one measure does not mean that all the individual components of the overall objective will be achieved. For example, a certain measure aims to protect biodiversity, whereas the other

aims at improving the quality of life of citizens by waterproofing a residential facility. Summing up the results obtained reaches the general objective - responsible management of natural and anthropogenic systems.

Overall objective 2: Exchange of information, knowledge and communication

After examining the climate change issues it can be concluded that the exchange of information, knowledge and communication of stakeholders are insufficient. Given that one of the components of adaptation is support or promotion of good management, it is necessary to create appropriate communication strategies and information and knowledge exchange instruments. Through education at all levels and on all relevant matters, the readiness to identify the existing problems and to contribute to resolving them represents one of the most important mechanisms to raise awareness and information of citizens and to involve them more actively in the implementation of climate change adaptation measures. It is recommended to have a broad representation of all stakeholders during the implementation of the Action Plan, including also persons who directly or indirectly benefit from the same.

Overall objective 3: Improving access to "comprehensive planning" that integrates information from the public and stakeholders in the process of taking acceptable decisions.

Experience has shown that the participation of citizens and a kind of local collective management can be an effective approach, because comprehensiveness improves outcomes, as a result of information access that can provide better solutions than those coming from the top down. The most important aspect of integration is the possibility to better coordinate the objectives of the city's local government with the objectives of the local population. This gives all stakeholders an incentive for better management of natural resources and can strengthen the entire process of implementation of measures and activities, and of achieving the set objectives. There is a risk that the comprehensive approach could reflect the existing inequalities between the stakeholders. There are parties whose interests may dominate the discussions or parties that do not participate in them at all. Another aspect is that the parties are not "owners" of resources, but are still interested in their fate. Involving the public in an adequate way is often difficult, especially when there are social and cultural barriers. Equally difficult challenge is the way in which to ensure the participation of those who do not directly benefit from the resources, but who can pollute them or who are susceptible to climate change impacts.

5.2. Adaptation actions related to the highest risks / most affected receptors

A total of 27 interventions were selected, which were evaluated according to the analysis of a number of criteria and on the basis of which they were ranked in terms of defining short-, medium- and long-term activities.

While reviewing the proposed Action Plan, one should keep in mind that some of the selected measures differ in terms of the scope of fulfilling the planned objectives, and that the realization of a single activity cannot lead to the fulfilment of all objectives. It should also

be taken into account that there is some overlap between the measures and objectives, hence, the most useful interventions, for example, are the most expensive, but the risks are usually higher. This means that, usually, when we want to carry out the recognized intervention and completely annul the possible negative influence (best available technology) this almost always assumes cost, and when one invests something that is partially based on assumptions, than due to the investment and expected benefit, is entering in the risk zone.

There is a clear contradiction between the costs and benefits, especially when it comes to short-term measures as compared to the long-term ones. It is indisputable that the costs and benefits are opposite, but what can often follow adaptation measures is that short-term measures bring visible results immediately and the investment return is shorter, while with the long-term measures the rate of return is longer, and sometimes they may lose their relevance and significance.

Criteria were used to measure the size and evaluate the interventions so as to prioritize them. The criteria used for the analysis are:

- adequacy of measure to tackle the identified problem
- complexity / implementation
- estimated costs
- additional benefits
- sustainability (without adverse effects).

We analysed the local sensitivities of the City to climate change in the **spatial context** as well. As shown on the Map of receptors sensitive to extreme climatic conditions (section 4.1), particularly sensitive receptors are located predominantly in the city centre and slightly wider surroundings. A certain number of identified receptors, especially those from urban greenery and social infrastructure categories, are present in the southern and south-eastern part of the territory of the City.

Based on the analysis of extreme weather events (heat waves, droughts, heavy rains/floods, storms, extreme cold) recorded in the period from 2003 to 2014, we considered the **local sensitivities** related to the given events. We recognized ecosystems, finance, vulnerable categories of citizens, buildings and infrastructure as particularly sensitive **receptors**. **Impacts and consequences** to which receptors were exposed were manifested in the form of irreversible damage to the plants, damaged roads and electric infrastructure, air pollution, floods.

As for this segment of the document, we wish to highlight:

- Urban greenery sector that involves surface areas of 561,455 m^2 (city parks - 116,017 m^2, linear greenery – 83,700 m^2, greenery in blocks - 361,684 m^2 and approximately 5,000 pieces of trees in alleys). Moreover, there are suburban greenery and park-forests with the surface area of 1,228.3 hectares. Recorded negative aspects are: weather disasters (windstorms, unexpected intense snowfalls, summer droughts, fires) and undeveloped irrigation system.
- The fire protection sector generated a trend of increasing number of fires, which are the most numerous in the summer months (in 2009 - 1,486 fires; 2010 – 1,688; 2011 – 2,679). Average age of special vehicles is over 25 years and there is no system for rapid information and alert.

- Intensification of flooding due to the large amount of rainfall (especially vulnerable area is Lake Skadar coast; in 2009 - 23 floods; 2010 - 45; 2011 - 15) marked the flood combating sector. Negative aspects are: lack of information system for protection against flooding and local government has no competence over the rivers of national importance.
- The buildings in Podgorica (the majority) do not have thermal insulation, which results in an increase in energy consumption and inefficiency of the cooling and heating system. Cooling (with cooling devices) of poorly insulated buildings in densely built structures leads to high temperatures outside them.
- The heat stress and air pollution causes vulnerability of the population and of the public health. Emergence of the so-called "heat island" in Podgorica caused by a high rate of paved surfaces and structural density of non-insulated buildings in the city centre.

Several rounds of discussion of the broader list of possible measures (see Annex 4), taking into account a number of parameters (sustainability in addressing the problem; complexity / implementation; costs; additional benefits and sustainability without negative effects), resulted in the following list of 27 measures. The list is prioritised and gives a detailed overview of priority measures for climate change adaptation in the area of Podgorica.

Table 17: Structural measures

No.	*Name and short description*	*Location*	*Responsible body*	*Measure complexity*	*Priority*
1	**Green roofs** (on flat roofs)	urban areas of the city	Investors and owners	medium-term measure	**low**
2	**Greening the squares with pergolas (*)**	existing and planned squares	"Agency for Construction and Development" and "Greenery"	short-term measure	**high**
3	**The introduction of species of vegetation that are resistant to extreme weather conditions**	public green areas	"Greenery"	long-term measure	**medium**
4	**Implementation of hydrants in the park forests and urban greenery**	park forests and urban greenery	"Greenery" and "Water and Sewerage Utility Company"	long-term measure	**medium**
5	**Drainage of storm water**	overall city area	"Water and Sewerage Utility Company"	long-term measure	**medium**
6	**Reconstruction of existing sewerage network**	overall city area	"Water and Sewerage Utility Company"	long-term measure	**medium**
7	**Flood protection - Flood caused by strong rainfall (sewer - systems)**	wastewater treatment plant in Podgorica	"Water and Sewerage Utility Company"	long-term measure	**medium**

8	**Regulation of river Dragije, Tara stream i Karačin stream**	river Dragije, Tara stream and Karačin stream	Relevant services of the City Municipality of Golubovci	long-term measure	**medium**
9	**Regulation of torrential flows (*)**	Savin stream, river Rujela	Secretariat for Entrepreneurship, "Agency for Construction and Development"	long-term measure	**high**
10	**Construction of more public pools** (construction of new pools and reconstruction of existing pools)	existing and planned sport zones	"Sports Facilities", "Agency for Construction and Development"	long-term measure	**low**
11	**Improvement of the system of city fountains and public fountains**	in squares and city parks	"Agency for Construction and Development" and "Water and Sewerage Utility Company"	long-term measure	**medium**
12	**Use of light-coloured façade tones and solar reflective coatings (*)**	overall city area	" Agency for Housing" and owners	short-term measure	**high**
13	**Rehabilitation of existing facilities by producing thermal insulation facades (including waterproofing protection façade)**	overall city area	" Agency for Housing" and owners	short-term measure	**medium**
14	**Renewal of hospitals, kindergartens, schools and other social infrastructure**	overall city area	Ministry of Health and Ministry of Education	long-term measure	**medium**
15	**Installation of solar panels**	overall city area	Investors and owners	medium-term measure	**low**
16	**Planned measures for flood protection (*)**	Areas threatened by floods (e.g. Savin stream)	Secretariat for Entrepreneurship	medium-term measure	**high**
17	**Introduction of species with appropriate vegetation period** (preparation of feasibility study)	agricultural land in City Municipalities of Tuzi and Golubovci	Relevant services in City Municipalities of Tuzi and Golubovci and agricultural producers	long-term measure	**medium**

Table 18: Non-structural measures

18	**Educational and information campaigns on climate change**	overall city area	Capital City, Public Health Institute, Red Cross, Primary health Centres, media	long-term measure	**high**
19	**Local system for warning citizens to adverse weather conditions / cyclone**	overall city area	Emergency Management Teams of Capital City and City Municipalities, media	long-term measure	**high**

20	**Early warning system for wildfires**	overall city area (with a focus on park forests)	Protection Service of Capital City	long-term measure	**high**
21	**Establishing care of vulnerable groups** (assistance in case of extreme situations)	overall city area	Capital City, Public Health Institute, Red Cross, Primary health Centres, media	long-term measure	**medium**
22	**Correction of working hours and adapting to extreme weather conditions**	overall city area	Employers (building companies)	long-term measure	**medium**
23	**Informing citizens about the quality of drinking water**	overall city area	"Water and Sewerage Utility Company" and Public Health Institute	long-term measure	**high**
24	**Developing a registry of green areas based on GIS technology**	public green areas	"Greenery"	long-term measure	**medium**

Table 19: Climate change mitigation measures

25	**Improving public transport**	overall city area	Capital City	long-term measure	**medium**
26	**Improving bicycle traffic (*)**	Podgorica, Golubovci and Tuzi (urban areas), park forests Gorica and Kakaricka Gora, Plavnica	"Agency for Construction and Development" and Secretariat for Transport	long-term measure	**high**
27	**Construction of more roundabouts (*)**	On the busiest roads	"Agency for Construction and Development" and Secretariat for Spatial Planning and Environment	long-term measure	**high**

Note 1: (*) ongoing project
Note 2: short term measures (1-2 years), medium term (2-5 years) and long term (5-10 years)

This list includes several measures (adaptation of social infrastructure, adoption of legislation) which are not under the jurisdiction of the Capital City, but the state authorities / ministries.

MORE DETAILED OVERVIEW OF SELECTED HIGH PRIORITY MEASURES:

STRUCTURAL MEASURES

URBAN GREEN AREAS

2. Greening the squares with pergolas

Description: The existing and newly planned squares

Relevant location(s) in Podgorica: City centre

Additional benefits: The effects of cooling squares identified as heat islands; improving air quality; improving spatial attractiveness

Costs: Direct costs of construction, planting and maintenance

Measure complexity: Short-term measure, technically medium-complex, implementation depends on financial possibilities

Negative external effects: An increase in maintenance costs

Competent authority / organization: Agency for Construction and Development of Podgorica and ”Greenery”

WATER SYSTEMS

9. **Regulation of torrential flows**

Description: Regulation of Savin Potok stream and Rujela River

Relevant location(s) in Podgorica: The area of the Capital City and City Municipality of Tuzi

Additional benefits: Protection of housing and other infrastructure against floods

Costs: Costs of the design of technical documentation and cost of regulation works

Measure complexity: Very complex

Negative external effects: Impact on unplanned constructed structures along the riverbeds

Competent authority / organization: Agency for Construction and Development of Podgorica

URBAN STRUCTURES

12. Light-coloured facades and anti-reflection coatings

Description: The measure whereby the choice of material results in reducing the effect of sun rays heating of the building

Further explanation: By choosing bright colours for painting the facade, and by applying reflective coatings for protecting roof insulation, a significantly lower degree of heat in the building is achieved during the summer period

Relevant location(s) in Podgorica: For the entire city, Podgorica

Additional benefits: Lower energy consumption for cooling; greater colour stability, and therefore lower maintenance costs; brighter colours are cheaper than the dark ones; using anti-reflection coatings the life of waterproofing layers is prolonged and maintenance costs are reduced

Costs: Relatively low direct costs

Measure complexity: Short-term measure, both legally and technically simple, easy implementation

Negative external effects: Some financial resources required; it is necessary to adequately prepare the surface in terms of repairing any previous damage, which increases the cost of procedure.

Competent authority/ organization: Agency for housing / owners

BUILDING DESIGN

16. Planning measures for flood protection

Description: Urban planning will seek to minimize the damage due to floods

Further explanation: Rise buildings above the surface of the land; not to build basements in floodplains; surface water and drainage systems to be regulated by planning documents; elevate mechanical, electrical and dangerous equipment, etc.

Relevant location(s) in Podgorica: Settlements gravitating to Savin Potok stream.

Additional benefits: Minimizing floods in buildings, better living conditions for the population in the settlements; Minimising damage to the environment and cleaning costs (hazardous material from flooded houses)

Costs: Direct costs of drafting relevant planning documents and control of their implementation

Measure complexity: Medium-term measure, legally and technically medium-complex.

Negative external effects: Increases the costs of building construction, as well as the costs of supporting infrastructure (primarily the system for surface water regulation)

Competent authority/organization: Secretariat for Spatial Planning and Development, Investors

NON-STRUCTURAL MEASURES

18. Educational and information campaigns on climate change

Description: Brochures for residents, tourists and workers out in the open about extreme weather conditions, organizing round tables and workshops

Relevant location(s) in Podgorica: For the entire city of Podgorica

Further benefits: Synergy with other adaptation measures concerning awareness-raising for all groups of the population will lead to improved health status of the citizens of Podgorica

Costs: Direct costs - continuous investment

Measure complexity: Long-term-variable costs, depending on the possibility for implementation of a certain measure

Negative external effects: Continuous investment - no negative effects

Competent authority / organization: Capital City, Institute for Public Health of Montenegro, Red Cross of Montenegro, media, Primary Health Care Centre of Podgorica

19. Local system to warn the population about adverse weather conditions/cyclone

Description: Setting up a local warning system for bad weather conditions (via the website of the Capital City, local communities, local media)

Further explanation: Weather forecast related to: coming heat events, strong rain / flooding, water shortage

Relevant location(s) in Podgorica: Capital City/ City Municipalities

Additional benefits: Higher level of protection of public health

Costs: Indirect

Competent authority / organization: PR offices / Emergency Management Teams of the Capital City and City Municipalities

20. Early Warning System for Forest Fires

Description: Prevention of intentional fires, alarm and early alert on the occurrence of fire

Further explanation: Installation of a fire alarm out in the open (video surveillance with thermal imaging sensors); installation of IFFMS (Intelligent Forest Fire Monitoring System) is the most optimal; installation of the system at the most critical locations

Relevant location(s) in Podgorica: Gorica and Ljubovic hills and parks towards Tuzi, Aluminium Plant Podgorica (KAP) and Zlatica

Additional benefits: Ability of the protection service for timely reaction; cost reduction in material losses, reducing shutdown and remediation costs; beneficial effect on air (e.g. Podgorica 2007); enhanced protection of green areas

Costs: High fixed direct costs

Measure complexity: Long-term measure - legally simple, technically medium-complex, the application depends on the financial capacity

Negative external effects: No adverse effects

Competent authority/organization: Protection Service of Capital City of Podgorica

23. Informing citizens about the quality of drinking water

Description: In case of extreme weather events, drinking water quality might be endangered and the usual way of using it might be jeopardized

Relevant location(s) in Podgorica: For the entire city, Podgorica

Further benefits: Synergy with other adaptation measures concerning awareness-raising for all groups of the population will lead to improved health status and safety of the citizens of Podgorica

Costs: Direct costs - continuous investment

Measure complexity: Long-term-variable costs, depending on the possibility for implementation of a certain measure

Negative external effects: Continuous investment-no negative effects

Competent authority/organization:"Water and Sewerage Utility Company, Institute for Public Health of Montenegro

CLIMATE CHANGE MITIGATION MEASURES

26. Improving bicycle transport

Description: Bicycle trails - promoting bicycle transport

Further explanation: It is required to plan bicycle trails along the newly planned roads; bicycle trails need to be designed in case of road reconstruction (widening to 4 lanes)

Relevant location(s) in Podgorica: Podgorica, riverbeds of the Moraca and Ribnica rivers, City Municipalities of Golubovci and Tuzi (urban area), park forests Gorica and Kakaricka Gora, Plavnica (Golubovci-Plavnica local road)

Additional benefits: Reducing the need for using motor vehicles, less traffic load, reducing CO_2 emissions, construction of bicycle trails to motivate the population to use this form of transport; possibilities for new projects open up (e.g. free "rental" bikes); contribution to quality of life

Costs: High direct and low indirect costs

Measure complexity: Gradual implementation, long-term measure, legally simple.

Negative external effects: Temporary impact on traffic/change of existing transport infrastructure

Competent authority/organization: Agency for Construction and Development of Podgorica

27. Construction of several roundabouts

Description: Increased frequency of traffic; reduced pollution by exhaust gases

Relevant location(s) in Podgorica: On the busiest roads

Additional benefits: Higher throughput capacity, reduced air pollution

Costs: High

Measure complexity: Complex

Negative external effects: Impact on the unplanned constructed buildings/ demolition/expropriation costs

Competent authority/organization: Agency for Construction and Development of Podgorica / Secretariat for Spatial Planning and Environment

6. Monitoring the effects of planned activities, presentation of data obtained – review of the action plan

Monitoring and evaluation of the implementation of the action plan is an important instrument for the evaluation of progress towards the accomplishment of strategic goals. At this moment the biggest problem is the availability of reliable and precise information on the status of individual receptors. Consequently, monitoring the implementation of the action plan will serve to consider whether the planned benefits are being achieved and to what extent the envisaged measures and activities can be adjusted to potentially changed conditions and new findings.

Creating a functional system of monitoring the implementation of adaptation activities is a very important element of the overall process of achieving the objectives set and fulfilling requirements regarding climate change. The activities defined in the plan presume a good basis for the development of projects with which to adequately apply for the available funds, which is in itself related to evaluation and monitoring.

Considering the collected knowledge and experience gained during the preparation of this document, it seems that it would be most convenient for the existing inter-agency working group to be established, after certain modifications, as the organizational body that will monitor implementation in the coming phases of implementation and monitoring. In this way, increasing capacities in all institutions of the Capital City will be continued.

A reliable monitoring and evaluation system is also an important mechanism for monitoring compliance with international standards and norms. This is especially important if, in the coming period, Podgorica becomes part of the European Union initiative - Mayors Adapt – the Covenant of Mayors Initiative on Climate Change Adaptation. In fact, by accepting the requests of the Initiative, Podgorica will, among other things, undertake to submit biennial reports on the implementation of climate change adaptation measures, including the Strategy's updates.

The steps that can be taken for the implementation of an efficient monitoring and evaluation system may include:

- **Creating, updating and maintaining the system for collecting the necessary data and information, including statistics, as well as specific indicators related to the performance of actions and the implementation of adaptation measures**.

  Some segments of the environment in the Capital City are subject to monitoring regarding the quality of their condition (air, soil, water courses, quality and availability of drinking water), so that the application of certain parameters will provide an answer to the question how they are affected by the implementation of given measures. Moreover, monitoring of other typical indicators will be also continued, provided that trends need to be followed and appropriate expert analyses made with

reference to that, and it should be considered, if it turns out to be necessary, whether other related components should be included into the monitoring and evaluation system.

- **Developing capacities in all institutions and bodies of the Capital City.**

  We have already pointed out that it is advisable to entrust the performance of the given duty to the Working Group that was involved in project activities from the very beginning. Its establishment precisely was conditioned by the fact that Working Group members are involved in individual sectors whose functioning is related to the impact and consequences of climate events. In its work, via analyses of extreme weather events, consideration of local sensitivities, recognition of particularly sensitive receptors, the Working Group has identified certain measures whose implementation would contribute to mitigating and adapting to expected changes and shaped them into the draft Action Plan. Naturally, the implementation of measures from the Action Plan involves the inclusion of other stakeholders from institutions in the Capital City.

- **Improving the capacities for strategic planning and performance evaluation to measure and analyse the efficiency of adaptation measures.**

  Implementation of monitoring implies defining a methodology with as clear inputs on operating modes as possible. In addition to the formal and legal organization of the body for monitoring the implementation of the Action Plan, it is necessary to specify the mode of operation in terms of coordination, organization of meetings and other acceptable forms of communication.

  The instrument applied so far for such working bodies is the rules of procedure which specifies regular sessions twice a year in plenary, and depending on the implementation of individual measures, the core working team comprising directly connected members. If necessary, the coordinator would have the authority to also schedule extraordinary meetings of the Working Group in plenary.

  Good implementation results of the said project indicate that the current manner of work would be completely acceptable in the future as well. Consideration of all key topics, a comprehensive analysis of problems identified the proposing of acceptable solutions, exchange of views and a responsible attitude to the set requirements, proved to be very efficient. A certain step forward would be to find a way to include more stakeholders in individual activities, in order to have effects of implementation at the highest possible level. This is especially true for accepting the recommendation of the project to include into the processes involved those responsible for strategic planning, spatial design of development, city council members and others.

  Experiences in monitoring the action plans implemented so far in other areas of activity showed that a very acceptable tool is the list of appropriate and relevant "questions and answers": Did the implemented measure improve the quality of certain segments of the environment (air, water, biodiversity, urban greenery)?; Did

the implementation of measure contribute to better lives of citizens (housing infrastructure, utility infrastructure)? etc...

Results of considerations, suggestions and recommendations should be presented via individual reports of members, which will be integrated in a common report on a particular issue. Annual information paper on the implementation of the Action Plan will be prepared by bringing together these reports, including a proposal of activities that will lead to greater efficiency, by identifying obstacles and defining mechanisms for overcoming identified barriers to the implementation of individual measures, and recommendations for changes and improvement thereof.

- M**onitoring the effects of incentive measures and results of awareness raising**.

  A special segment, regardless of the planned measures, is to find the mechanisms for the establishment of incentive measures and create socially responsible entities and individuals. Without the active involvement of citizens, a completely successful implementation of the measures of the Action Plan will be brought into question. That is why it is necessary to establish a very efficient system of monitoring progress in the described scope of action and to recognize actions that would contribute to better results.

- **Economic component**

  One of the main challenges for implementation of the Strategy is to find ways to finance planned activities and climate change adaptation measures. New forms of schemes and modern structures of financing, known as public-private partnerships, certainly represent a possible model for the distribution of costs and benefits of the implemented measure. In this way, we will avoid the previous traditional financing from the public sector and enable the private sector investments, against certain benefits.

  To that effect, we will single out ecosystem services related to flood protection and protection against soil erosion, which is directly related to climate change and healthy ecosystems, and represent essential protection against some of the most extreme impacts. For these reasons, it is necessary to have a comprehensive and integrated approach to the preservation and improvement of ecosystems, and "goods and services" they provide.

  The particularity of considering the financial framework is related to the analysis of costs and benefits of pre-defined measures. Sometimes new and unplanned costs arise in the process of implementing measures, e.g. for construction or maintenance. Likewise, it is possible to cause unplanned maintenance costs in other infrastructure systems by a measure's implementation. On the other part, as a result of prevention, costs can be estimated too high.

When the monitoring system is fully operational and when methodologies with more accurate projections are developed, the Strategy can be revised in line with the current circumstances. Detailed plans and interim results of individual activities should be regarded

as the basis for determining the future elements of the Strategy and the indicative target of creating a "resilient city". To that effect, it is necessary, on the basis of monitoring conducted, to evaluate the functionality of objectives for adaptation measures such as, for example: the scope of green areas or green roofs, and whether their implementation achieved a reduction of the "heat island" effect, heat waves, floods, etc.

In the light of monitoring the achieved level of established communication and awareness raising, indicators which can be considered include assessing the degree of information of the relevant target groups, understandability and availability of adequate information. The way of planning and organizing the participatory process is also evaluated, as well as the sustainability of established communications and to what extent the views and suggestions of stakeholders were considered.

The temporal aspect of adaptation measures has a significant role in monitoring the implementation of the Action Plan particularly with regard to the reality of foreseen deadlines, assessing the possibilities of providing the necessary funding, resources, and overcoming the identified obstacles to the implementation of the Plan.

In addition to the afore-mentioned, the role of the time dimension is important in terms of the circumstances in which the measure is implemented, and lack of possibility to anticipate certain limitations in the form of emergencies. To that effect, marks given will enable a more realistic planning of the time frame.

Continuous task of the working team is also to monitor the achievement of objectives set and standards. An integral part of the Strategy are also the overall objectives set out in the form of guidelines or recommendations identified through other documents that were subject to the so-called "desk analysis" (measures from the spatial and urban plan of the Capital City, Strategic Development Plan, Local Environmental Protection Plan, action plan for managing energy as a resource, sectoral policies such as the management of water resources, forests, agriculture, etc.). For example, the following matters should be integrated into the plans for the definition of activities regarding the water resources: waste water treatment, water re-use, including incentives to do so; risks management, including flood protection and identification of areas at risk of flooding; drought management; incentives for collection (use) of rainwater and incentive programs, etc.

7. Outlook – Instead of conclusion

The implementation of activities under the project "**Adaptation to Climate Change in the Western Balkans"** included implementation of the component relating to integration of climate change adaptation issues into management and planning processes in the cities. The main results are the development of adaptation measures in the form of Vulnerability Study and Action Plan, as well as the development of city administration capacities and other institutionally recognized parts of the system.

Notwithstanding the achievements accomplished so far, in the forthcoming period the Capital City will be facing numerous challenges, primarily in terms of implementation of the Action Plan measures and its accompanying elements. Although the capacities of the city administration authorities have been strengthened, there is still more work to be done. In addition to the above, the need has been recognized for promoting climate change issues and defining communication mechanisms as well as encouraging citizens' involvement in the Action Plan implementation. At the same time, there is an indisputable need to enhance capacities/knowledge on climate change issues and to increase the level of political interest in terms of commitment to the implementation of adaptation measures. Including the Climate Change Adaptation Strategy into the Capital City Assembly Agenda will constitute the first step towards overcoming certain difficult issues.

It is expected that coming up with the most acceptable model for financing the planned measures will be one of the hardest obstacles during the Action Plan implementation process.

Joining EU Mayor Adapt Initiative and fulfilling its requirements represents a particular challenge, and would result in Podgorica becoming part of the European "family of resilient and sustainable cities".

8. Glossary

Adaptation:
Adjustment in natural or human systems in response to observed or expected climatic changes or their impacts. Adaptation moderates harm (risks) or exploits benefits (opportunities). Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007; Ribeiro et al. 2009). When using the term adaptation in this report, planned adaptation – i.e. adaptation that is the result of a deliberate policy decision – is meant.

Adaptive capacity (relating to climate change impact):
Adaptive capacity describes a system's ability to adapt to climate change (including climate variability and extremes) for mitigation of potential damages, use of opportunities and addressing consequences.

Climate change impact:
Impacts or consequences of climate change on natural or human systems (IPCC, 2007).

Extreme weather event:
An event connected with extreme weather conditions like heat, storm or heavy precipitation that occurs rarely at a certain place and time (Birkmann et al. 2011). Definitions of 'rare' vary, but an extreme weather event would usually be less rare than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is considered extreme weather can vary from place to place in an absolute sense. Extreme weather events cannot directly be attributed to anthropogenic climate change, as there is always a chance to that an event might have occurred naturally. When an extreme weather pattern keeps occurring over a longer period of time, such as during a certain season, it can be classed as an extreme weather event, particularly if it results in an average or total that is itself extreme (e.g. drought or heavy rainfall during a certain season of the year).

The Heat Island or Urban Heat Island (UHI) effect:
It describes the possible temperature difference between rural and build-up urban areas. The effect can be explained by the absorption of solar radiation by materials in cities (e.g. dark surfaces: tar etc.). Furthermore, in cities buildings block the air exchange with the outer and cooler surroundings of the city.

Receptor:
In this report receptors describe local physical features and socio-economic conditions of cities and regions that are affected by weather impacts. They include the major functions and features of a city like population, infrastructure, built environment, economy and natural resource.

Climate change relevant receptors (physical features and socio-economic conditions) in cities – categories and examples

Population	Infrastructure	Built environment	Economy	Natural resources
				
●Public health/ vulnerable groups	●Transport ●Electricity and heating services ●Water supply and sanitation services ●Social infrastructure	●Building stock and materials	●Industry ●Retail ●Tourism	●Green spaces ●Water resources and quality ●Air quality ●Agriculture ●Forestry ●Biodiversity / ecosystems

Sensitivity:
The degree to which a system is affected by climate or weather stimuli. The impacts may be direct or indirect and can be beneficial or adverse (IPCC, 2001; Ribeiro et al. 2009).

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

Risk:
In the method used in Podgorica "risk" is the combination of current vulnerability (regarding the current climate) and the potential future climate change impact (as concluded from climate change trends). Often, the term risk is defined as the combination of the probability of occurrence and the magnitude of the consequences or of the hazard. In the method used here, the probability of occurrence is not evaluated because the climate change impact is based on tendencies and qualitative descriptions. The uncertainties of climate change projections are, at least for some climate parameters, very high (uncertainties from scenarios, from models or sampling uncertainty).

Example for the approach used in Podgorica: The general sensitivity of the population group "elderly people" to impacts of current heat waves is rated "high" and their ability to adapt is rated "medium" (due to limited mobility to go to cool spaces). Therefore, the current vulnerability is "high". With the changing climate more and longer heat waves are projected,

which will reinforce the current vulnerability of this population group. Therefore, the future risk is rated “very high”.

9. References

- The Vulnerability Sourcebook, Concept and guidelines for standardized vulnerability assessment; GIZ in cooperation with Adelphi and EURAC research;
- Urban adaptation to climate change in Europe, challenges and opportunities for cities together with supportive national and European policies; European Environmental Agency Report;
- European Commission, 2013, Guidelines on developing adaptation strategies http://ec.europa.eu/clima/policies/adaptation/what/docs/swd_2013_134_en.pdf);
- Hallegatte, S. 2009, Strategies to adapt to an uncertain climate change. *Global Environmental Change*;
- The United Nations Framework Convention on Climate Change (UNFCCC);
- The Kyoto Protocol;
- Doha amendments;
- The Intergovernmental Panel on Climate Change (IPCC), 2007, Climate Change: Impacts, Adaptation and Vulnerability.
- FC (2013) Adaption Compass Future Cities – urban networks to face climate change, Guidance for developing climate-proof city regions, Lippeverband, Essen, 2013
- Ivanov (2014) excerpt of 1st and 2nd national communication of Montenegro under the United Nations Framework Convention on Climate Change [provided by Mirjana Ivanov, Institute of Hydrometeorology and Seismology], Podgorica
- Ivanov (2015) Mirjana Ivanov, Master of Meteorology, Institute of Hydrometeorology and Seismology (IHMS), Podgorica
- Djurdjevic (2014) Doc. dr. Vladimir Djurdjevic, Institute of Meteorology, University of Belgrade

ANNEX 1 - Local vulnerability assessment - past events

(Synthesis table of the Working Group)

Meteorological disaster	Extreme weather	Consequences (indirect impacts)	Affected receptors	Location
Heat wave				
2003 **2007** **2008** **2013**	42.2 C° 44.8 C° up to 40 C°	1. Direct and indirect impact (total and partial drying of plants…) 2. Occurrence of plant diseases 3. Reduced vitality and decorativeness of plant material 4. The possibility of forest fires -More electric power consumption for cooling, leading to frequent breakdowns in the transmission network - Damage to the asphalt - Inability to execute works on building structures in the open due to the inability to observe the technological process and the risks to health of employees	1. Ecosystems 2. Entire plant stock 3. Public company/local self-government budget The central city core is especially affected, including a lot of buildings, large asphalt and concrete surfaces Vulnerable groups (children, pregnant women, the elderly, chronically ill, socially endangered groups, outdoor workers ...)	Urban areas of Podgorica, Tuzi and Golubovci are affected the most 1. City parks (Njegošev, Karađorđev, Kraljev, Centralni, Ivanov and Kruševac) 2. Park forests 3. Block and 4. Linear greenery
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Drought				

01/06-10/09/2003 **01/06-19/10/2007** **November 2011 June, July, August and mid-September 2012** **June, July, August 2013**	the maximum number of consecutive days without rainfall was 56 the number of tropical days higher than normal heat waves drought developed from hydrological into an agricultural one (Note: the extreme weather events are not related to these dates)	forest fires smog 4 times higher than normal caused problems to the eyes and respiratory organs (coughing and choking). decimated crops, reduced increment, convenience for the attack of diseases and pests, hydrological situation close to the lowest values. increased need in waterless suburban areas no changes in drinking water quality. the flow of recipient of the river Morača during dry periods is at the minimum level and it results in less dilution of effluents, so that BOD5 of the recipient of the river Morača is increased.	1. Ecosystems, 2. Entire plant stock, 3. Company/local self-government budget. parks and green areas in the city and gardens and infields in the suburbs are especially affected vulnerable population groups (children, pregnant women, the elderly, chronically ill, socially endangered groups, outdoor workers ...) hindered operation of the waste water treatment facility	Parks and green areas in the city: 1. City parks (Njegošev, Karađorđev, Kraljev, Centralni, Ivanov and Kruševac) 2. Park forests, 3.Block and 4. Linear greenery. gardens and infields in the suburbs
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Great precipitation / Floods				
June 2009 **December 2009 - January 2010**	series of intense cyclonic activities followed by heavy rainfall	flooded residential and business facilities, certain streets impassable closed schools and kindergartens,	all categories of the local population in flooded settlements were affected public utility infrastructure	<u>In the area of Podgorica:</u> the underpass at Tuški Road, Vojislavljevića Street, in the streets 27.marta, Kralja Nikole, Oktobarske Revolucije, Bulevar Revolucije and

03-15/01/2010 **09/06/2010** **30/11-01/12/2010** **27/08-28/08/2012** **29/11/2012** **10-25/03/2013** **01/04-11/04/2013** **30/09/2013** **21/01/2014**	increased water level of the Skadar Lake (588 cm) and high groundwater levels overflow of river Rujela's banks, of river Cijevna and of Lake Skadar (Note: the extreme weather events are not related to these dates)	evacuation and care of the population and material goods; state of emergency !!! power outages in some parts of the city registered increase of turbidity and increase in the colour of water due to leaching drinking water from individual wells unusable overflows of septic tanks, a large amount of deposited waste; damage to the waterproofing of flat roofs; penetration of moisture and water through the facades of older facilities; water penetration into basements	road infrastructure material goods and residential facilities agricultural areas cultural and historical buildings / sacral buildings –churches around the Skadar Lake buildings with flat roofs; buildings with basement premises; buildings with worn facades hindered operation of the waste water treatment facility	on the underpass in Zlatica and the riverbed of Savin Creek <u>City Municipality of Golubovci:</u> Gostilj, Berislavci, Bijelo polje, Bistrice, Kurilo, Vranjina, Ponari, Šušunja, Goričani, Mojanovići, Golubovci, Mataguži <u>City Municipality of Tuzi</u> – urban area of Tuzi and the surrounding villages: Podhum, Vranj, Vladne, Kodrabudan, Vuksanlekići, in local community Dinoša, hamlet Tojeć and village Omerbožovići
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Storms				
15/05/2010 **09/06/2010** **05/10/2010** **12/07/2012**	storm wind hail snow blizzard storm / landspout	damage to households - crops and greenhouses of agricultural producers were destroyed broken branches and trees, overturned and broken trees interruption of air and road traffic	parks and green areas in the city crops and greenhouses in the suburbs buildings with slant roofs - business, collective housing facilities, as well	Parks and green areas in the city: 1. City parks (Njegošev, Karađorđev, Kraljev, Centralni, Ivanov and Kruševac) 2. Park forests 3.Block and 4. Linear greenery

11/12/2012 **30/05/2013**	(note: the extreme weather events are not related to these dates)	interruption of electricity supply damage to buildings - mainly in roofing and sheet metal elements	as individual residential buildings were most affected	Urban municipality Tuzi, rural area settlements in the urban municipality Golubovci: Golubovci Mataguži, Balabani, Gošići, Goričani, Mojanovići, Šušunja, Mahala
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Snowfall				
January 2005 **01-08/02/2012** **11/12/2012** **02/02-01/03/2013**	storm wind extreme cold / Snow blizzard (according to unofficial information 58-105 cm of snow) (note: the extreme weather events are not related to these dates)	large snowdrifts impassability of roads interruption of public transport interruption of air traffic injuries of the population more difficult provision of food interruption of electricity supply hindered operation of the waste water treatment facility appearance of turbidity in drinking water damage to the greenhouses snow slides (a large number of uprooted trees)	vulnerable population groups (children, pregnant women, the elderly, chronically ill, socially endangered groups,...) parks and green areas in the city greenhouses in the suburbs aging, dilapidated buildings that house the socially vulnerable population were the most threatened	the entire territory of the city

		and snow throws damage to the roofs of many buildings		
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Hail				
09/06/2011 **26/05/2013** **19/06/2014** **22/08/2014**		great material damage inflicted to agricultural producers, which primarily relates to the crops that were destroyed on that occasion broken branches and trees mechanical and physiological damage to plants, occurrence of plant diseases and pests damage to buildings and vehicles	crops and greenhouses in the suburbs parks and green areas in the city buildings with slant roofs - business, collective housing facilities, as well as individual residential buildings were most affected	Parks and green areas in the city: 1. City parks (Njegošev, Karađorđev, Kraljev, Centralni, Ivanov and Kruševac) 2. Park forests, 3.Block and 4. Linear greenery. Greenhouses in Tološi City municipality of Tuzi, rural area. Settlements Sukuruć, Koderbudan, Podhum, Vranj, Vladne, Ljekovići, Vuksanlekići
Meteorological disaster	**Extreme weather**	**Consequences (indirect impacts)**	**Affected receptors**	**Location**
Fires				
04/08/2007 **24/08/2011** **16/07/2012**		greater forest area destroyed smoke in the territory of the capital/ smog material damage	parks and green areas in the city vulnerable population groups (socially endangered groups,...)	Park-forest across the Aluminium Plant. Park-forest Gorica Park-forest Ćemovsko Field

24/07/2012* **31/07/2013**		evacuation of the population * 29 shacks burned down, 150 families with a total of 800 persons were left homeless		Park forest Golubovci * Settlement Konik – Camp I

ANNEX 2: List of Current Vulnerability

	Receptors	General weather sensitivity of receptor		Who / What is affected	Sensitivity/ Exposure	Capacity to adapt	Vulnerability
		Extreme event	Potential effects				
Population	Public health / vulnerable groups	Heat wave	-Deaths, mainly due to cardiovascular diseases -Spread of vector-born and infectious diseases -Altered allergic pattern -Heat stress	Elderly people, babies, children, sensitive/sick people; people working outside; sportsmen; especially in new building blocks, city centre	High	Medium	High
		Extreme cold	-Injured and deaths -Spread of respiratory and infectious diseases	Sensitive people, babies, elderly and immobile people, homeless; people working outside	Medium	Low	Medium
		Drought	-Effects on the air-hygienic situation -Leads to an accumulation of trace elements	All people living or working in affected areas	Low	Low	Low
		Heavy precipitation / Floods	-Injured and deaths -Spread of diseases due to contaminated water, mainly infections	All people living or working in affected areas	High	Medium	High
		Storm	-Casualties and deaths	All people living or working in affected areas	Low	Low	Low
Infrastructure	Transport	Heat wave	-Damages -Changes in behaviour pattern / demand -Air quality problems -Higher maintenance costs	Roads, rail roads, etc., public transport, mobility of people	High	High	Medium
		Extreme cold	-Damages -Changes in behaviour pattern / demand -Higher maintenance costs	Roads, rail roads, etc., public transport, mobility of people	Medium	Medium	Medium
		Drought	-Difficult transport of bulk material	Waterways, water management	Medium	Medium	Medium
		Heavy precipitation / Floods	-Damages -Hindered traffic flow	All means of transport, public transport, mobility of people, infrastructure in the affected areas	High	Medium	High
		Storm	-Damages -Hindered traffic flow	All means of transport, public transport, mobility of people, infrastructure in the			

				affected areas			
	Electricity and heating services	Heat wave	-Damages -Altered load peaks / demand -Efficiency changes -Cooling system problems -Higher maintenance costs, mainly own consumption	Electricity distributors, consumers	High	Low	High
		Extreme cold	-Damages -Altered load peaks / demand -Cracking of heating system -Interruption of power supply	Electricity distributors, consumers	High	Low	High
		Drought	-Cooling system problems -Higher maintenance costs, e.g. environmental requirements -Lower electricity production	Electricity distributors, consumers	High	Low	High
		Heavy precipitation / Floods	-Damages / failures -Interruption of work of the power supply system	Electricity distributors, consumers	High	Low	High
		Storm	-Damages / failures	Electricity distributors, consumers	High	Low	High
	Sanitation services	Heat wave	-Higher water demand -Water quality problems -Higher maintenance costs	Waste water treatment facility	Low	High	Low
		Extreme cold	-Damages e.g. on infrastructure -Water quality problems -Higher maintenance costs	Waste water treatment facility	Medium	High	Low
		Drought	-Water scarcity -Water quality problems -Higher maintenance costs	Waste water treatment facility	Medium	Medium	Medium
		Heavy precipitation / Floods	-Damages -Higher maintenance costs -Water quality problems -Pollution of soil and water from leakage of sewage	Waste water treatment facility -sewage system	High	Low	High
		Storm	-Damages -Water quality problems	Waste water treatment facility	Low	High	Low

	Water supply services	Heat wave	-Higher water demand -Water quality problems -Higher maintenance costs	Potable water laboratory	Low	High	Low
		Extreme cold	-Damages e.g. on infrastructure -Water quality problems -Higher maintenance costs	Potable water laboratory	low	High	Low
		Drought	-Water scarcity -Water quality problems -Higher maintenance costs	Potable water laboratory	Low	High	Low
		Heavy precipitation / Floods	-Damages -Higher maintenance costs -Water quality problems	-Potable water laboratory -Mareza spring	High	Low	High
		Storm	-Damages -Water quality problems	Potable water laboratory	Low	High	Low
	Social infrastructure	Heat wave	-	Roma people	Medium	Medium	Medium
		Heat wave	-	Other socially endangered categories, kindergartens and schools, hospital	Medium	Medium	High
		Heat wave	-	Social infrastructure (social housing)	High	High	Medium
		Extreme cold	-More patients in hospitals -Higher maintenance costs, e.g. for heating	Roma, other socially endangered categories, kindergartens and schools, hospital, social infrastructure (social housing?)	High	Medium	High
		Drought	-	Roma people	Low	High	Low
		Drought	-	Other socially endangered categories	Medium	High	Low
		Drought	-Changed requirements, e.g. for water supply	Kindergartens and schools, hospital	High	Medium	High
		Drought	-	Social infrastructure (social housing?)	Low	Medium	Low
		Heavy precipitation / Floods	-Damages -Emergency management needed -More patients in hospitals -Higher maintenance costs	Kindergartens and schools, hospital	High	Medium	High

		Storm	-Damages -Emergency management needed -More patients in hospitals -Higher maintenance costs	Roma, other socially endangered categories, kindergartens and schools, hospital, social infrastructure (social housing?)	High	Medium	High
Built environment	Building stock and materials	Heat wave	-Damages e.g. on asphalt -Higher maintenance costs	Technical & urban infrastructure, especially in densely built areas, dark surfaces, asphalt, concrete, etc.	High	Low	High
		Heat wave	-Greater need for air conditioning -Heat island effect -Shorter life span of elements of objects exposed to the sun, e.g. water proofing of flat roofs	Collective residential buildings and commercial buildings in urban parts of the city surrounded by big concrete and asphalt surfaces	High	High	Medium
		Extreme cold	-Damages, e.g. on asphalt -Higher heating demand -Higher maintenance costs	Buildings, technical & urban infrastructure	Low	Medium	Low
		Drought	-Higher water demand	Buildings	Medium	Medium	Medium
		Heavy precipitation / Floods	-Surface runoff, rainwater installation clogging, increase of roads flooding -Clogging and damage to the rainwater installations of facilities, damage to water proofing, water leak into residential and business premises	-City centre and suburbs -Particular vulnerable buildings with basements gravitating towards Savin Stream; building with damages on facades and roofs	Medium	Medium	Medium
		Storm	-Damages	-	High	Medium	High
Economy	Tourism	Heat wave	-Altered high / low seasons -Image changes -Increasing costs, e.g. for cooling	Tourists, touristic infrastructure, historical & cultural buildings, tourist economy	Medium	Low	Medium
		Extreme cold	-Altered high / low seasons -Image changes -Increasing costs, e.g. for heating	Tourists, touristic infrastructure, historical & cultural buildings, tourist economy	Medium	Low	Medium
		Drought	-Altered high / low seasons -Image changes -Increasing costs, e.g. for water supply -Higher water demand	Tourists, touristic infrastructure, historical & cultural buildings, tourist economy			

		Heavy precipitation / Floods	-Damages on touristic infrastructure -Higher costs for maintenance and repair	Tourists, touristic infrastructure, historical & cultural buildings, tourist economy	Medium	Low	Medium
		Storm	-Damages on touristic infrastructure -Higher costs for maintenance and repair	Tourists, touristic infrastructure, historical & cultural buildings, tourist economy	Medium	Low	Medium
	Industry	Heat wave	-Lower efficiency-Cooling problems and higher costs-Shortfall of workers	not relevant for Podgorica	n/a	n/a	n/a
		Extreme cold	-Need for greater heating -Increasing costs, e.g. for heating	not relevant for Podgorica	n/a	n/a	n/a
		Drought	-Water scarcity / cooling problems -Supply problems due to limited bulk transport	not relevant for Podgorica	n/a	n/a	n/a
		Heavy precipitation / Floods	-Damages / failures	not relevant for Podgorica	n/a	n/a	n/a
		Storm	-Damages / failures	not relevant for Podgorica	n/a	n/a	n/a
	Retail/SME	Heat wave	-Lower efficiency -Cooling problems and higher costs -Shortfall of workers -Changes in buying behaviour -Sales boost / shortfall	Consumer (access & price level), shop owners, enterprises with need for cooling	Low	High	Low
		Extreme cold	-Need for greater heating -Increasing costs, e.g. for heating -Changes in buying behaviour -Sales boost / shortfall	Consumer (access & price level), shop owners, enterprises with need for (more) heating	Medium	Low	Medium
		Drought	-Water scarcity / cooling problems -Supply problems due to limited bulk transport -Changes in buying behaviour -Sales boost / shortfall	Consumer (access & price level), shop owners, enterprises with need for water			
		Heavy precipitation / Floods	-Damages / failures -Sales shortfall	Consumer (access & price level), shop owners, enterprises in the affected areas	Medium	Low	Medium
		Storm	-Damages / failures	Consumer (access & price level), shop owners, enterprises in the affected areas	Medium	Low	Medium

Natural resources	Green spaces	Heat wave	-Direct and indirect impact (total and partial drying of plants)-Occurrence of plant diseases-Reduced vitality and decorativeness-Possibility of forest fires	Ivanov park, block greenery, park forest (low capacity to adapt),	High	Medium	High
		Heat wave	-Direct and indirect impact (total and partial drying of plants) -Occurrence of plant diseases -Reduced vitality and decorativeness -Possibility of forest fires	City parks, linear greenery	High	High	Medium
		Extreme cold	-	-			
		Drought	-Weaker growth of plants -Earlier defoliation and falling of needles -Reduced growth, diseases and pests -Draining of the root system -Occurrence of fire	Ivanov park, block greenery, park forest (low capacity to adapt),	High	Medium	High
		Drought	-Weaker growth of plants -Earlier defoliation and falling of needles -Reduced growth, diseases and pests -Draining of the root system -Occurrence of fire	City parks, linear greenery	High	High	Medium
		Drought	Fires -Direct impact (complete destruction of trees, as well as the entire plant fund) -Indirect impact (reduced vitality and decorativeness of surrounding trees) -Occurrence of diseases and pests	City parks, Ivanov park, linear greenery	Low	High	Low
		Drought	Fires -Direct impact (complete destruction of trees, as well as the entire plant fund) -indirect impact (reduced vitality and decorativeness of surrounding trees) -Occurrence of diseases and pests	Block greenery	Medium	Low	Medium
		Drought	Fires -Direct impact (complete destruction of trees, as well as the entire plant fund) -indirect impact (reduced vitality and decorativeness of surrounding trees) -Occurrence of diseases and pests	Park forest	High	Low	High

		Heavy precipitation / Floods	-	-			
		Snowfall	-Snow slides (a large number of uprooted trees) -Snow throws -Frost cracks	City parks, Ivanov park, block greenery, linear greenery, park forest (low capacity to adapt),	High	Medium	High
		Hail	-Mechanical damage to plants -Physiological damage to plants -Occurrence of plant diseases	-	High	Low	High
		Storm	-Mechanical damage to plants	City parks, Ivanov park, block greenery	Medium	Medium	Medium
		Storm	-Mechanical damage to plants	linear greenery, park forest (low capacity to adapt),	High	Medium	High
	Water resources and quality	Heat wave	-Higher evaporation / higher water uptake by ecosystem / lower water flows -Spread of algae, bacteria -Altered fauna -Lower groundwater recharge	The whole ecosystem, fauna, flora, the health of people, groundwater recharge, water supply system, data missing	High	Low	High
		Extreme cold	n/a	n/a			
		Drought	-Lower water flows / lower groundwater recharge -Salinization -Dikes may collapse	The whole ecosystem, fauna, flora, the health of people, groundwater recharge, water boards	High	Low	High
		Heavy precipitation / Floods	-Salinization / water quality problems	The whole ecosystem, fauna, flora, the health of people, groundwater recharge, water boards	High	Low	High
		Storm	-Storm floods / waves	The whole ecosystem, fauna, flora, the health of people, groundwater recharge, water boards			
	Air quality	Heat wave	-Spread of diseases -Smog / higher concentration of air pollutants and allergens	Health of people, image of the city, the whole ecosystem, fauna, flora	High	Low	High
		Extreme cold	-Smog in case of inversion -Higher concentration of air pollutants due to higher need for heating (depending on type of fuel used)	Health of people, image of the city, the whole ecosystem, fauna, flora			
		Drought	-Smog / higher concentration of air pollutants and allergens	Health of people, image of the city, the whole ecosystem, fauna, flora	High	Medium	High

		Heavy precipitation / Floods	n/a	Health of people, image of the city, the whole ecosystem, fauna, flora			
		Storm	n/a	Health of people, image of the city, the whole ecosystem, fauna, flora			
	Agriculture	Heat wave	-Changes in growth cycle -enhanced dehydration	Agricultural producers, food industry and citizens - consumers	High	Medium	High
		Heat wave	-Direct impact on livestock farming by reducing the productivity of livestock products, and indirect impact on livestock by harvest deterioration	Agricultural producers, food industry and citizens - consumers	Medium	Medium	Medium
		Extreme cold	-Changes in the growth cycle due to the late spring or early autumn frosts	Agricultural producers, food industry and citizens - consumers	High	Medium	High
		Extreme cold	-Direct and indirect impact on livestock farming	Agricultural producers, food industry and citizens - consumers	Medium	High	Medium
		Drought	-Changes in the cycle of growth in terms of scald and decay of organs	Agricultural producers, food industry and citizens - consumers	High	Medium	High
		Drought	-Direct and indirect impact on livestock farming	Agricultural producers, food industry and citizens - consumers	Medium	Medium	Medium
		Heavy precipitation / Floods	-Changes in the cycle of plant growth, death, decay and the impact on yield and quality	Agricultural producers, food industry and citizens - consumers -Vulnerability of livestock farming: low	High	Low	High
		Storm	-Changes in the growth cycle in terms of plant productivity	Agricultural producers, food industry and citizens - consumers -Vulnerability of livestock farming: low	High	Low	High
	Forestry	Heat wave	-Changes in growth cycle (decrease in growth or drying of wood) -Possibility of a fire - Fires	Consumer, ecosystem			
		Extreme cold	-Dying of trees	Consumer, ecosystem			
		Drought	-Damages / dying of trees -Fires	Consumer, ecosystem			
		Heavy precipitation / Floods	-Damages / dying of trees -Violation of water bodies and soil quality -Damage to the root system -Erosion of forest land	Consumer, ecosystem			
		Storm	-Damages / dying of trees	Consumer, ecosystem			

	Bio-diversity / eco-systems	Heat wave	-Altered flora and fauna, new & invasive species -Loss of species -Dying of flora and fauna -Migrations -Fires	All flora and fauna with low adaptive capacity, ecosystem			
		Extreme cold	-Reduced food source for animals	All flora and fauna with low adaptive capacity, ecosystem			
		Drought	-Altered flora and fauna, new & invasive species -Loss of species -Dying of flora and fauna -Migrations -Fires	All flora and fauna with low adaptive capacity, ecosystem			
		Heavy precipitation / Floods	-Altered flora and fauna, new & invasive species -Loss of species -Torrential streams	All flora and fauna with low adaptive capacity, ecosystem			
		Storm	-Loss of natural resources	All flora and fauna with low adaptive capacity, ecosystem			

ANNEX 3: Expected future risks

Receptors	High and very high risks in summer		... in summer AND winter	
	Heat/Heat wave	**Storm**	**Drought**	**Heavy precipitation / Floods**
Public health / vulnerable groups	Reinforcement of heat stress, increasing spread of new vector-born and infectious diseases and altered allergic patterns			Growing spread of diseases due to contaminated water, increasing use of health care services, increase of damages and injured from flooding, deterioration of microbiological parameters of well water, possible deterioration of the epidemiological situation
Transport	Increase of damages affecting roads, public transport, mobility of people; increasing costs for maintenance and increase of air quality problem		Inland navigation on rivers might be impossible	Increase of damages and costs for maintenance, cleaning/protection / rebuilding measures, less mobility
Electricity services	Increasing number of damages, increasing maintenance costs, possible supply problems due to higher energy demands and less efficiency, increased cooling demand	Increasing number of damages / failures	Increasing maintenance costs, increasing cooling demand, less hydropower potential	Increasing number of damages/ failures on electricity production and distribution facilities
Sanitation services			Problems with waste water treatment facility due to decreasing availability of water	Waste water treatment facility - sewage system: Increasing number of damages and maintenance costs, low water quality problems, increasing impact of floods due to lack of sewerage systems capacity
Water supply				Problems with Mareza water supply spring – reduced water quality, increased maintenance costs
Social infra-structure	Increasing need for cooling in hospitals, schools, kindergartens	Increasing number of damages and increasing maintenance costs	More people with respiratory problems in hospitals; Less availability of water (economisation of resources)	Increased damages and costs of maintenance
Building stock and materials	Increasing number of damages (e.g. on asphalt), reinforcement of heat island effect, risk of overheating, increasing maintenance costs and need for cooling. Very high risk for collective residential buildings and commercial buildings in urban parts of the city surrounded by big concrete and asphalt surfaces	Increasing number of damages and increasing maintenance costs	Buildings: Increasing damages, e.g. of the foundation because of soil drying; reduced humidity and an increase in temperature in summer will lead to the emergence of new damages due to temperature deformation	Increasing number of damages and need for standard of protection and solving the storm water drainage; creation of drainage systems in the affected areas Increasing maintenance costs In city centre and suburbs: particular vulnerable buildings with basement gravitating towards Savin stream; building with damages on facades and roofs
Tourism	Altered tourism season, possible damage of cultural and historic monuments, worsening of bathing water quality	Increasing damages and costs for maintenance		Increasing damages and costs for maintenance, less income due to decreased number of tourists
Retail/Small scale enterprises		Increasing damages and costs for protection and repair, increasing problems with transport of goods		Increasing number of damages (stocks / equipment) or loss of business continuity, increasing costs for protection and repair, increasing problems with transport of goods

Receptors	High and very high risks in summer		... in summer AND winter	
	Heat/Heat wave	**Storm**	**Drought**	**Heavy precipitation / Floods**
Green spaces	Increasing number of dying plants, increasing maintenance costs (mainly watering) Very high risk for Ivanov park, block greenery, park forest High risk for city parks, linear greenery	Summer storms with hail: increasing damages on infrastructure and plants, increase in maintenance costs	Ivanov park, block greenery, park forest: increasing maintenance costs (mainly watering), increasing risk of fire (especially park forest), increasing drying	
Water resources	Reduction of water quality (e.g. eutrophication), less groundwater recharge		Water shortage, decreasing water flows / low groundwater recharge	Increasing water quality problems (surface water and ground water), pollution of water
Air quality	Increasing spread of diseases, reinforcement of smog (increasing concentration of air pollutants and allergens)		Increasing spread of diseases, reinforcement of smog (increasing concentration of air pollutants and allergens)	
Agriculture	Livestock farming (high risk) and other agricultural products (very high risk) Decreasing diversity of species, increasing risk of fire, changes in growth cycle, increasing number of infestation of pest, decreasing harvest, growing need of irrigation	Increasing number of damages / loss of harvest (e.g. due to hail with summer storms)	Increasing fire risks, increasing need of watering, increase in damages, increasing risk of soil erosion, drying of plants, decreasing harvest, increasing number of vermin, loss of pastures	Increasing risk of erosion of the surface soil, increasing number of damages / loss of harvest, changes in growth cycle, occurrence of mechanical damages, physical damage to structures

ANNEX 4 Catalogue of adaptation measures

				Specification of measure in Podgorica					Criteria for prioritisation - Proposal for assessment see pdf					
Type of measure	**Description**	**Further explanation**	**Relevant location(s) in Podgorica**	**Additional benefits**	**Costs**	**Complexity of measure**	**Negative external effects**	**(Main) Responsible department / organisation**	**Suitability for problem solving**	**Complexity/ implementation**	**Costs**	**Additional benefits**	**Sustainability (no negative effects)**	**Conclusion / Ranking**
				-Synergies with other adaptation measures, -Contribution to urban development aims, to mitigation, - Low-regret measure, -Ongoing opportunity, pilot projects etc.	**Direct / indirect**	**- Time aspects of planning and implementation (short-medium-long-term) - Technical / legal complexity - Owner of measure / owner of location etc. - Acceptance by stakeholders**	**E.g. cross-sector check regarding society or eco-system or negative effects outside of the city**		**++, +, o , -**	**++, +, o, -**	**++, +, o, -**	**++, +, o**	**+, o, -, --**	
Structural measures														
Urban green structures														
Green roofs	Roofs covered with soil and plants	Roofs intended primarily for flat roof surfaces, the necessary layers of soil and plant species adapted to our climate; Systems tend to be self-sustaining	Urban areas of the city	- Less energy consumption for cooling -Improve the micro-climate around buildings and air quality -Slower evaporation process - Possible savings in insulation layers - Energy benefits - Noise protection	- High direct costs, - Some indirect costs	Medium-term measure, legal and technical complexity exist; necessity of education for the application	- High cost of execution - Expensive maintenance -Additional burden on construction.	Secretariat for planning and spatial planning , investors	+	-	-	++	++	
The introduction of species of vegetation that are resistant to extreme weather conditions	Intensify the use of native species	-Species naturally distributed in some area -Species that tolerate extreme conditions in our midst (high summer temperatures, high degree of drought, strong winds)	All the greenery that "Greenery" ltd is maintaining	- Minimized water consumption - Reduced maintenance costs	- Direct	Long-term measure	No negative effects	"Greenery" ltd	++	o	o	+	+	

Implementation of hydrants in park forests and urban greenery	Elements of the urban water supply system in the function of supplying the plants with water	- Fire protection during the dry period of the year - Supplying the plants with water	Park forests and bloc greenery	- Effects of environmental protection -Reduced maintenance costs	- Direct	Long-term measure	No negative effects	"Greenery" ltd "Water Supply and Sewerage" ltd	++	o	-	++	+	
Improving the maintenance of green areas system	Creating a green area cadastre based on GIS technology	- Detailed records of green areas and maintenance units - Facilitated planning and implementation of maintenance of public green spaces	All public green spaces	- Reduced maintenance costs - Higher quality maintenance of green areas	- Direct	Long-term measure	No negative effects	"Greenery" ltd	++	o	-	++	+	
Greening the squares with pergolas	Existing and newly planned		City wide Podgorica	The effects of cooling squares identified as heat islands	- High	Very complex	Increase in maintenance costs	Agency for Construction and Development of Podgorica, "Greenery" ltd	++	o	-	+	o	
Introduction of species with appropriate vegetation period, adjustment of agro-technical measures, improving the microclimate conditions for agricultural production	Agricultural land in the area of Tuzi and Golubovci		In the areas of Tuzi and Golubovci	Training of agricultural producers, adaptation of planting dates, access to new varieties, land management, efficient use of fertilizers, irrigation, crop insurance, increase yields	- High - Preparation of feasibility study - Establishment of a fund for agriculture	Very complex	Increase in maintenance costs	Farmers	++	o	-	++	-	
Water systems														

-Flowing water in urban spaces -Regulation of rivers Dragije, Tara stream i Karačin stream	Through regulation works, regulate water flow that occurs due to heavy rainfall	Existing stream channels of Dragija, Bracanov stream, Tara stream are usurped by the storage facilities, various waste and the like.	City Municipality of Golubovci	-Protection and conservation of water -Preventive measures to protect against the harmful effects of water	- High direct and indirect - Technical documentation will give the scope and sequence of works with an overview of costs	Low legal and technical complexity	No negative effects	Local authorities	++	++	O	+	+	
Reconstruction of sewerage network			City wide Podgorica	-Effects of environmental protection -Reduction in drinking water consumption (recycle), -Reduced maintenance costs	- High fixed/direct costs (variable / indirect costs), - Step-by-step (following the order) implementation after the feasibility study	Very complex, studies (in legal and technical regard), long-term measure, step-by-step implementation	Increase fees for municipal services, temporary impact on traffic	"Water Supply and Sewerage" td	++	-	-	+	o	
Construction of more public pools	Construction of new and reconstruction of the existing ones		In addition to the planned sports fields in the city, near the Moraca Sports Centre	Cooling effect	High fixed/direct costs (variable / indirect costs), step-by-step (in order) implementation after the feasibility study	Very complex	Increase in maintenance costs	Agency for Construction and Development of Podgorica	++	-	-	+	o	
Improvement of the system of city fountains and public fountains	New facilities		On the streets and in city parks	Cooling effect, availability of drinking water	- Construction costs after the preparation of technical documentation	Complex	Increase in maintenance costs	Agency for construction and development of Podgorica "Water Supply and Sewerage" ltd	+	+	o			
Drainage of storm water	Elements of the urban water system in function of rain water drainage	Elements of the urban water system in function of rain water drainage, e.g. channel system infiltration wells. There are two possible ways to improve rainwater drainage: a) surface or underground channel system, ditches, ponds and the like, b) reduce the	City wide Podgorica	Effects in reduced maintenance costs, effects of environmental protection	- High direct costs, - Variable indirect costs - will be determined by feasibility study	Long-term measure, partial implementation	Temporary impact on traffic	"Water Supply and Sewerage" ltd	++	-	o	+	o	

		sealing surface e.g. with the construction of water - permeable pavement, infiltration ditches, basins, wells, galleries												
Flood protection- Flood caused by strong rainfall (sewer - systems)	Protection against flood from different sources	Specific measures depend on the source of floods, e.g. river flooding, flood caused by strong rainfall (drainage system), flash flooding caused by strong rainfall (hills).	PWWT in Podgorica	Reducing turbidity of drinking water from spring Mareza, reducing the cost of water disinfection, protection of public health and the environment	-High fixed costs, but reduced maintenance costs of substation, located at the entrance of PWWT and is exposed to flooding	Medium-term measure, implementation in one single step, legally simple, and technically complex	Temporary effect on work of PWWT	"Water Supply and Sewerage" ltd	+	o	o	+	o	
Regulation of torrential flows	Savin stream, Rujela river, Cijevna river		In the area of Capital City and City Municipalities	Flood protection of housing and other infrastructure	- Costs of regulation after making technical documentation	Very complex	Impact on unplanned constructed buildings along the riverbeds	Agency for Construction and Development of Podgorica	++	-		++	-	
Urban structures														
Bright-colour facades and solar reflective coatings	Measure to use the choice of material to reduce heating of the building due to the effect of sun rays	By choosing bright colours for painting the facade, as well as the application of reflective coatings for the roof insulation, a significantly lower level of heat in the building during the summer period is achieved as a result	City wide Podgorica	- Lower energy consumption for cooling - Greater colour stability, and therefore lower maintenance costs - Brighter colour tones are cheaper than dark ones - Using reflective coatings prolong the life of water-proof layers and reduce maintenance costs	-Relatively low direct costs	Short-term measure, legally and technically simple, simple implementation	-Certain amount of founds needed; -It is necessary to adequately prepare the surface in terms of repairing the damage which increases the procedure	Housing agency	+	++	++	+	o	
Renewal of hospitals, kindergartens, schools and other social infrastructure	Easier stay for all socially vulnerable categories in these institutions	-Increasing green areas around hospitals, kindergartens etc. -Painting with brighter colours, - providing insulation for internal cooling and heating	Podgorica and City Municipalities	Easier adjustment of vulnerable groups to climate change	- Medium direct costs, - Lower maintenance costs	Long-term measure	No negative effects		+	++	o	+	+	
Building design														

Rehabilitation of existing facilities	Use of appropriate materials to improve the general condition of the property in terms of adaptation to climate change	- Repairing any damage to the exterior facade and roof surfaces to prevent water and moisture penetration into the building using high-quality, durable materials -Installation of roller shutters - Replacement of external doors and windows with the ones with appropriate energy class	Buildings older than 20 years	Lower energy consumption for heating and cooling; increasing the economic value of the building; extending life of the facility; improving the comfort and health of residents; lower maintenance costs; aesthetic benefits	- Direct costs of works	Short-term measure, medium technical complexity its application depends on the financial possibilities	Relatively high costs of higher standards application	Owners of buildings	+	+	o	++	o	
Planned measures for flood protection	Strive to minimize the damage caused by floods through urban planning	- Elevate buildings above the surface - Do not build basements in floodplains - Planning documents to regulate the surface waters - Drainage systems - Elevate the mechanical, electrical and dangerous equipment, etc.	Settlements that gravitate to Savin stream	- Minimize flooding in buildings - Better living conditions for the population in the settlements	- Direct costs of making appropriate planning documentation and control of its implementation	Short-term measure, medium legal and technical complexity	Costly construction of buildings, as well as the costs of supporting infrastructure (preferably the system for the regulation of surface water)	Secretariat for planning and spatial planning , investors	+	o	-	+	-	
Rehabilitation of existing facilities by producing thermal insulation facades (including water-proof coating on the facade)	Application of adequate thermal insulation materials in order to improve the thermal performance of apartment buildings	-Remedy any defects that exist in the facades with the use of appropriate materials - Produce thermal insulation facade, with the necessary water-proof layers, finishing in the desired tone - Perform all associated works	Buildings older than 20 years, in urban areas of the city	- Lower energy consumption for heating and cooling - Increasing the economic value of the building - Extending life of the facility; - Improving the comfort and health of residents; - Lower maintenance costs; - Aesthetic benefits	- Direct costs of works	Short-term measure, medium technical complexity Its application depends on the financial possibilities	Relatively high costs of higher standards application; Implementation depends on the ability of flat owners to finance works	Apartment agency, owners of the objects	++	+	o	++	o	

Installation of solar panels	Installation of solar panels on the roofs of buildings	Reconstruction of existing buildings in terms of installation of solar panels on the roofs of buildings, primarily for water heating	City wide Podgorica	- Lower energy consumption for heating water in homes, which represents a significant percentage of total energy consumption - Solar energy is renewable; panels are recycled - Relatively long life - Cost-effectiveness in relation to the initial investment	- Direct costs of making appropriate planning documentation and the cost of the works	Medium-term measure, medium legal and technical complexity	Relatively high initial costs energy production depends on weather conditions and the amount of sunny days	Secretariat for planning and spatial planning , investors	+	o	-	++	--	
Non-structural measures														
System of monitoring regime of Skadar Lake to protect against flooding settlements in the coastal part	Inter-institutional cooperation on the regulation of the water regime of Skadar Lake; In 2010 a memorandum of understanding between Montenegro and Albania was signed to resolve regulation of the water regime of Skadar Lake and protection of flood-coastal areas; Intergovernmental commission for monitoring and implementing measures was formed	Local government should be involved in order to: - provide reliable information about the course of implemented and planned activities in the water management of Lake Skadar; - ensure adequate spatial planning in the affected areas; - protect property and citizens; - participate directly in proposing and adopting decisions and plans for protection from harmful effect of waters of Skadar Lake	Endangered areas of City Municipalities of Tuzi and Golubovci	Reduced budget expenditures for coverage of assessed consequences of flooding	- Indirect	Depends on the already established concept of the relevant state authority with neighbouring Albania in addressing the issue of regulation and management of Lake Skadar	Unexpected	Capital / City Municipality	+		-	++	+	

Local system for warning citizens to adverse weather conditions / cyclone	Setting up a local system and a warning to bad weather conditions (via the website of the Capital, local communities, local media)	The prognosis in relation to: - warming developments - strong rains / floods - lack of water	Capital City/ City Municipalities	A greater degree of protection of public health	- Indirect			PR offices / teams of Emergency Management of the Capital City and city municipalities	+	-	++	++	+	
Early Warning System for wildfires	Prevention of intentional fires, Alarm and early alert on the occurrence of fire	- Installation of a fire alarm in the open (video surveillance with thermal imaging sensors) - most favourable installation of the IFPS system (intelligent fire protection system)	Installation of the system at the most critical locations: Gorica Hill, Ljubovic and parks towards Tuzi, KAP and Zlatica	-Ability to take timely actions by emergency services -Cost reduction in material losses - Reducing the cost of fire extinguishing and repairs - Favourable impact on the air (e.g.Podgorica in 2007) - Improved protection of green areas	- High fixed direct costs	- Long-term measure - Legally simple - Medium technical complexity - Application depends on the financial possibilities	No negative effects	The Civil Protection Service Podgorica	++	o	-	++	+	
Establishing care of vulnerable groups	Establishment of a social network for help in case of extreme situations		City wide Podgorica	In synergy with other adaptation measures for all groups of population, it will lead to improvements in the health status of the citizens of Podgorica	- Direct costs - Continuous investment	Long-term measure variable costs depending on the possibilities of realization of certain measures	-Continuous investment -No negative effects	Capital City, IJZCG, Red Cross MNE, media, DZ Podgorica	++	+	+	++	+	
Correction of working hours and adapting to extreme weather conditions	Interruption of works outdoors / prohibition to construction during extreme weather conditions		City wide Podgorica	In synergy with other adaptation measures for all groups of population, it will lead to improvements in the health status of the working population in the event of extreme weather conditions	- Direct costs - Indirect costs	- Long-term measure, - Legally complex and technically simple measure, which should be taken by the City Council, and complied with by all construction companies	Reduced pace of construction during extreme weather	Capital City	++	o	+	o	o	
Educational and information campaigns on climate change	Brochures for residents, tourists and outdoor workers about extreme weather conditions, organization of round tables		City wide Podgorica	In synergy with other adaption measures relating to raising awareness for all groups of population, it will lead to improvements in the health status of the citizens of Podgorica	- Direct costs - Continuous investment	- Long-term measure - Variable costs depending on the possibility of implementing a certain measure	- Continuous investment - No negative effects	Capital City, IJZCG, Red Cross MNE, media, DZ Podgorica	++	++	+	++	+	

Informing citizens about the quality of drinking water	In case of extreme weather events		City wide Podgorica	In synergy with other adaption measures relating to raising awareness for all groups of population, it will lead to improvements in the health status of the citizens of Podgorica	- Direct costs - Continuous investment	-Long-term measure -Variable costs depending on the possibility of implementing a certain measure	-Continuous investment -No negative effects	"Water systems and sewerage" ltd, IJZCG	+	++	++	++	+	
Climate change adaptation measures in urban plans and programs														
Improving public transport	More efficient public transport	- Renewal of old bus fleet with the newer buses - Reorganization of bus routes in the form of better coverage - Modern bus stops - Greater timetable frequency	- Podgorica, - Golubovci and Tuzi	- Less need for parking places, - Less burdened traffic, - Reducing transmission of air polluting particles - More efficient fuel consumption.	- High direct costs - Variable indirect costs	- Step by step implementation - Long-term measure		Management of the Capital, Public City Transport ltd	+	o	-	++	-	
Improving bicycle transport	- Cycling trails - Promoting bicycle transport	- With the newly planned traffic lines, cycling trail planning is also required, - When reconstructing roads (widening to 4 lanes), cycling trails should be designed	- Podgorica, - Moraca and Ribnica rivers, - Golubovci and Tuzi (urban areas), - Park forests Gorica and Kakaricka hills, - Plavnica (Golubovci-Plavnica local road)	- Reducing the need for using motor vehicles - Less burdened traffic, - Reduction in CO_2 emissions, - Construction of cycling routes to motivate population to use this mode of transport, - Opens possibilities for new projects (e.g. free "renting" of bicycles, example: Pariz -"Velib") - Contribution to quality of life	- High direct costs - Low indirect costs	- Step by step implementation - Long-term measure - Legally simple measure	-Temporary effect on the traffic	Agency for Construction and Development Podgorica	+	-	o	++	-	
Construction of morel roundabouts	-Increasing the frequency of traffic, -Reducing pollution by exhaust gases		On the busiest roads / planned roads	Higher throughput, Reducing air pollution	-High direct costs	- Complex measure	- Effect on unplanned structures / demolition	Agency for Construction and Development Podgorica Secretariat for Spatial Planning and Environment	+	+	o	+	o	

ANNEX 5: List of WG meetings

Date and place of the meeting	**The topic of the meeting**
29-30 January 2014, Brussels	Consultative workshop as part of the Initiative for adaptation to climate change in cities and the first meeting of the Regional Working Group with representatives of the consulting company "Infrastruktur und Umwelt"
18-19 March 2014, Podgorica	Meetings of representatives of agencies and companies of the Capital City with representatives of the consulting company "Infrastruktur und Umwelt" and the German Society for International Cooperation - GIZ
16-17 July 2014, Podgorica	The first meeting of the Project Steering Committee, which was attended by a representative of the consulting company "Infrastruktur und Umwelt" and the representative of GIZ and the first meeting of the Working Group (presentation of the goals and methods of work on the project; introduction to climate change in the world, the EU experiences in adaptation to climate change)
30 July 2014, Podgorica	The second meeting of the Working Group (division of responsibilities among the members of the Working Group)
16 September 2014, Podgorica	The third meeting of the Working Group (getting to know the key dates with extreme weather events and the start of drafting a report on sensitivity)
9 October 2014, Podgorica	The fourth meeting of the Working Group (continued work on the report on sensitivity of individual receptors)
17 October 2014, Podgorica	The fifth meeting of the Working Group (continued work on the report on sensitivity of individual receptors)
3-4 November 2014, Podgorica	The second meeting of the Project Steering Committee and the sixth Meeting of the Working Group with representatives of the consulting company "Infrastruktur und Umwelt" and the German Society for International Cooperation - GIZ (presentation of previous work - based on existing vulnerability and risk assessment, beginning of drafting a report on vulnerability; presentation of the types of measures for adaptation to climate change)
19 November 2014, Podgorica	The seventh meeting of the Working Group (continued work on the report on vulnerability)
10 December 2014, Podgorica	The eighth meeting of the Working Group (preparation of synthetic tables V3, C1 and R1)
29 January 2015, Podgorica	The ninth meeting of the Working Group (defining the results of synthetic tables V3, C1 and R1)
18 February 2015, Podgorica	The tenth meeting of the Working Group (preparation of an extensive list of measures for adaptation to climate change)
25-26 February 2015,	The second Regional Meeting

Belgrade	(presentation of recent results in Belgrade, Tirana and Podgorica in the climate change adaptation project)
5-6 March 2015, Podgorica	The eleventh Meeting of the Working Group with representatives of the consulting company "Infrastruktur und Umwelt" and the German Society for International Cooperation - GIZ and the third meeting of the Project Steering Committee (introduction to the climatic trends and future risks)
26 March 2015, Podgorica	The twelfth meeting of the Working Group (preparation of a short list of measures for adaptation to climate change)
8 April 2015, Podgorica	The thirteenth meeting of the Working Group (analysis of selected measures and preparation of data for the catalogue)

ANNEX 6: List of WG members

Lazarela Kalezić, Secretariat for Spatial Planning and Environmental Protection (coordinator)
Dejan Mugoša, Secretariat for Spatial Planning and Environmental Protection (secretary)
Veselinka Vukčević, Secretariat for Spatial Planning and Environmental Protection (member)
Branka Knežević, Secretariat for Spatial Planning and Environmental Protection (member)
Tonja Ratić, Secretariat for Spatial Planning and Environmental Protection (member)
Vuk Boljević, Secretariat for Social Welfare (member)
Mirjana Perović, Secretariat for Entrepreneurship Development (member)
Gordana Čukić, Secretariat for Culture and Sport (member)
Miloš Marković, Protection Office (member)
Lazar Čadjenović, Protection Office (member)
Milanka Baljević, City Municipality of Golubovci (member)
Amra Pepić, City Municipality of Tuzi (member)
Tanja Drakulović, Housing Agency (member)
Valentina Prelević, Agency for Construction and Development of Podgorica (member)
Biljana Nikosavić, Water Supply and Sewage Ltd (member)
Vuko Popović, Greenery Ltd (member)
Simeun Zarubica, Sanitation Services Ltd (member)
Mladenka Vujošević, Public Health Institute (member)
Borko Bajić, Public Health Institute (member)
Mirjana Ivanović, Institute of Hydrometeorology and Seismology (member)
Budimir Vidaković, technical support