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iDEAL - DEcision support for Adaptation pLan

Priority Axis:Safety and resilience
Specific objective:2.1 - Improve the climate change monitoring and planning of adaptation measures tackling specific effects, in the cooperation area

WP3 DEFINITION AND MONITORING OF CLIMATE ADAPTATION PLANS
Activity 3.2 CLIMATE ADAPTATION PLANS

Climate Adaptation Plans

City of DUBROVNIK

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Abbreviations

CC – Climate Change
City – City of Dubrovnik
CMHS - Croatian Meteorological and Hydrological Service
DURA – Dubrovnik Development Agency
iDEAL - DEcision support for Adaptation pLan
IRENA-Istrian Regional ENergy Agency
IUAV - Università Iuav di Venezia
PP – Project Partner
SLR – Sea Level Rise
UF – Urban flooding
UHI – Urban Heat Island

1 Introduction

Climate change presents an increasing threat and will challenge the entire humanity during the 21st century. There is an undisputed scientific and political consensus stating that climate change is already happening and affecting us which is confirmed by adaptation of array of international agreements.

The Republic of Croatia has been exposed to the adverse effects of climate change which affect ecosystems, economic sectors, human health and cause significant economic losses. According to the report by the European Environment Agency (EEA), the Republic of Croatia belongs to the group of three European countries with the highest cumulative share of damages from extreme weather and climate events in relation to gross national product (GNP). The effects of climate change depend on a range of parameters and the intensity of impacts will vary depending on geographical location. According to the International Climate Modelling Results (IPCC, EEA), the Mediterranean basin is designated as a climate "hot spot" with particularly pronounced effects of climate change. There is an increasing evidence that the Republic of Croatia is sensitive to climate change and given that it belongs largely to the Mediterranean region, the impact of climate change will increase, and the vulnerability is assessed as high. Therefore, it is of utmost importance to initiate the social process of adopting the concept of adaptation to climate change, to determine what effect climate change has on the Republic of Croatia, to determine the degree of vulnerability and accordingly, priority action measures.

Adaptation to climate change, together with mitigation, is considered as another important pillar of climate policy implementation, which is focused towards preserving the value of society, the environment and the economy, as well as towards ensuring the sustainable development of the Republic of Croatia in the long term. It should be emphasized that, because of its size and economic power, the Republic of Croatia can make only a small contribution to climate change mitigation, but it is nevertheless exposed to a significant impact of the negative effects of climate change, as it becomes evident from the afore-mentioned economical damage data. This will become especially pronounced if decision makers and experts do not start planning and implementing climate change adaptations activities immediately. Increasing development pressure on the Croatian coastal zone has led to environmental degradation due to a lack of appropriate strategies and policies. Due to global climate change, urban areas in dry and hot climate zones are especially vulnerable to its negative effects. In these conditions, a balanced relationship between green and grey surfaces is crucial for urban sustainability. Climate change and the green infrastructure present new challenges for cities and their sustainability.

Dubrovnik is a Croatian city on the Adriatic coast. It is one of the most prominent tourist destinations in the Mediterranean Sea, a seaport and the centre of Dubrovnik-Neretva County. Examples of the impact of climate change are evident through the increasing occurrence of natural disasters, most often in the area of the City of Dubrovnik in the form of droughts and floods. Specifically, more frequent floods are caused by extreme amounts of high intensity rainfall and the cause of droughts is the prolongation of periods without precipitation. Furthermore, changes in the regime of rainfall and air temperature cause changes in temperature and sea level, both globally and locally (Adriatic Sea). Additional examples of (indirect) impacts of climate change are seen in the impact on transport infrastructure, the impact on water supply and sewerage systems, the impact on energy infrastructure.

Cross Border Cooperation (CBC) Programme Italy-Croatia is funding the EU project iDEAL (DEcision support for Adaptation pLan) for which IRENA-Istrian Regional ENergy Agency is acting as the lead partner. IRENA and DURA (City of Dubrovnik Development Agency) are the two project partners from Croatia, while the Italian partners are the Municipality of Pesaro (province Misano and Urbino), Municipality of Misano Adriatico (province of Rimini) and the regional nature park „Dune costiere da Torre Canne e Torre San Leonardo". The last project partner (PP) is IUAV University of Venice that provided technical assistance in the project.

The main objective of the project iDEAL is to improve the climate change monitoring and planning of adaptation measures tackling specific effects in the regions of concern. Main project outputs include the creation of CAP (Climate Adaptation Plan) for each concerned region and climate change monitoring systems put in operation. The European Commission encourages all Member States to adopt comprehensive adaptation strategies (currently 21 member states have strategies) and provides funding to help them build up their adaptation capacities and take action.

The objective of the adaptation plans is to investigate the climate of a specific geographic region and find the most suitable measures for adapting the area to climate challenges. The plan needs to identify what effect climate change could have on the environment and the quality of life in the region of interest. Therefore, the best adaptation measures need to be identified, elaborated and described. IUAV University will be using the DSS method (Decision Support System) to identify optimal adaptation measures out of all possibilities available for certain region.

2 Analysis

Dubrovnik and its surrounding area are situated in the southern part of the Republic of Croatia and its province of Dalmatia (Figure 2.1). According to the World Geodetic System (WGS84) Dubrovnik is situated at 42°38'53.05" of the northern latitude, like Rome and Barcelona, and at 18°5'31.78" eastern longitude, like Stockholm. These are the advantages of the geographical position that cause the subtropical climate and rich vegetation.

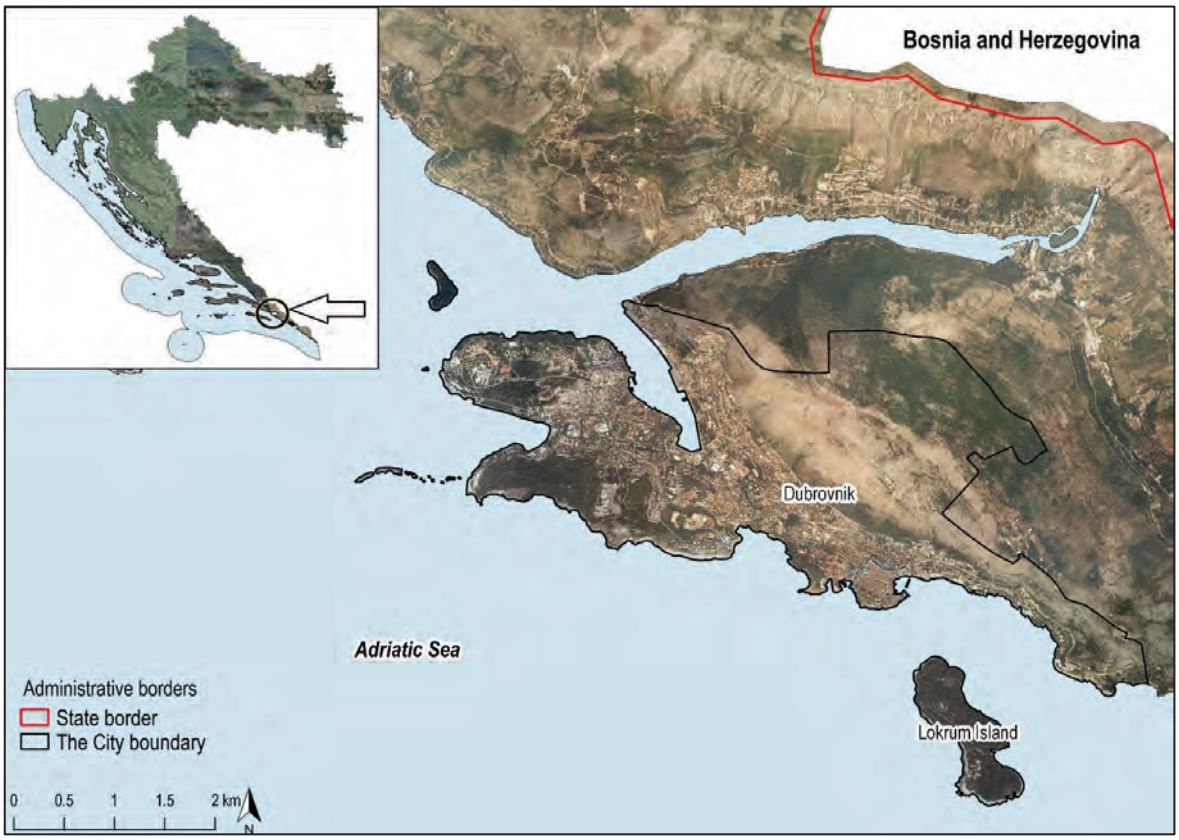


Figure 2.1 Geographical location

With its land area of 143,38 km^2, the City of Dubrovnik occupies 8,05 % of the total area of Dubrovnik-Neretva County, 1100 km^2 of the territorial sea and about 2200 km^2 of the economic zone to the border line with neighbouring Italy.

According to 2001 Census, Dubrovnik had 43 770 inhabitants in the City of Dubrovnik. According to 2011 census, there were 42 615 inhabitants, which represents a share of 34,77 % of the total population in the Dubrovnik-Neretva County. The data presented shows that the population in the City area decreased by 2,64 %. The average age of residents in the City of Dubrovnik is 42.4 years. Also, according to the 2011 census Dubrovnik has an age coefficient (percentage of people aged 60 and over in the total population) of 25,6. This is a basic indicator of the level of aging when it exceeds the value of 12 %, it is considered that the population of a certain area has entered the aging process.

Tourism is the main economic branch of the City of Dubrovnik and the entire Dubrovnik-Neretva County. In addition to tourism, the main economic activity in the area of the City is also dominated by agriculture, viticulture, wine making, olive growing, livestock, fishing, construction and transport.

The intensification of traffic between the East and West both during and after the Crusades resulted in the development of maritime and mercantile centres throughout the Mediterranean and the Adriatic Sea in the 12th and 13th centuries. Dubrovnik was one of them. Already during the 14th and 15th century, Dubrovnik was the most significant maritime and mercantile centre of the Adriatic, alongside Venice and Ancona.

The legal status of Dubrovnik Republic was completely achieved by the 15th century. Already in the 15th century, Dubrovnik had a well-organized transit trade route with Balkan hinterland. Dubrovnik Republic entered its golden age in the 16th century, at a time when the power and glory of the Venetian Empire was on the wane. Its prosperity was based on maritime trade. In the 16th century, the Dubrovnik merchant navy matched world levels with its quality fleet of 180 to 200 ships. Material prosperity, and the feeling of security and freedom, helped shape a humanist culture that further inspired ardent creativity. Dubrovnik reached magnificent levels of achievement in its urban and architectural development that has been maintained to the present day. In the 17th century, the general crisis in Mediterranean maritime affairs also affected Dubrovnik maritime trade.

The catastrophic earthquake of 1667 brought Dubrovnik Republic into a critical period, where it fought for its survival and political independence. The 18th century gave Dubrovnik an opportunity for the economic revival of maritime trade under a neutral flag. This was the state of affairs when Napoleon dissolved the Republic of Dubrovnik in 1808. At Vienna Congress in 1815, the Dubrovnik region was joined to the other parts of Dalmatia and Croatia. Since then, they have shared a common political fate.

Following the Republic of Croatia declaration of independence and subsequent Serbian aggression on the Croatian territory, Dubrovnik was attacked in October of 1991. The Serbians and the Montenegrins aimed to conquer the region. The Dubrovnik region was occupied and significantly devastated. In the 8-month siege, the city itself was repeatedly bombarded. Today, the war-devastated cultural heritage of Dubrovnik has been repaired for the most part and the old town has been classified as a UNESCO world heritage site since 1979. The renovated hotels, the important assets of Dubrovnik Summer Festival, as well as other cultural events are crucial prerequisites for the development of modern tourism.

Dubrovnik has a borderline humid subtropical (Cfa) and Mediterranean climate (Csa) in the Köppen climate classification, since only one summer month has less than 40 mm of rainfall, preventing it from being classified as solely humid subtropical or Mediterranean. Dubrovnik has hot, moderately dry summers and mild to cool wet winters. The bora wind blows cold gusts down the Adriatic coast between October and April, and thundery conditions are common all the year round, even in summer, when they interrupt the warm, sunny days. The air temperatures can slightly vary, depending on the area. Typically, in July and August daytime maximum temperatures reach 28°C, and at night drop to around 23°C. In Spring and Autumn maximum temperatures are typically between 20°C and 28°C. Winters are among the mildest of any Croatian city, with daytime temperatures around 13°C in the coldest months. Snow in Dubrovnik is very rare. Monthly values and extremes for Dubrovnik in 1961-2018 period are shown in the figures below (Figure 2.2, Figure 2.3, Figure 2.4) according to the Croatian Meteorological and Hydrological Service (CMHS).

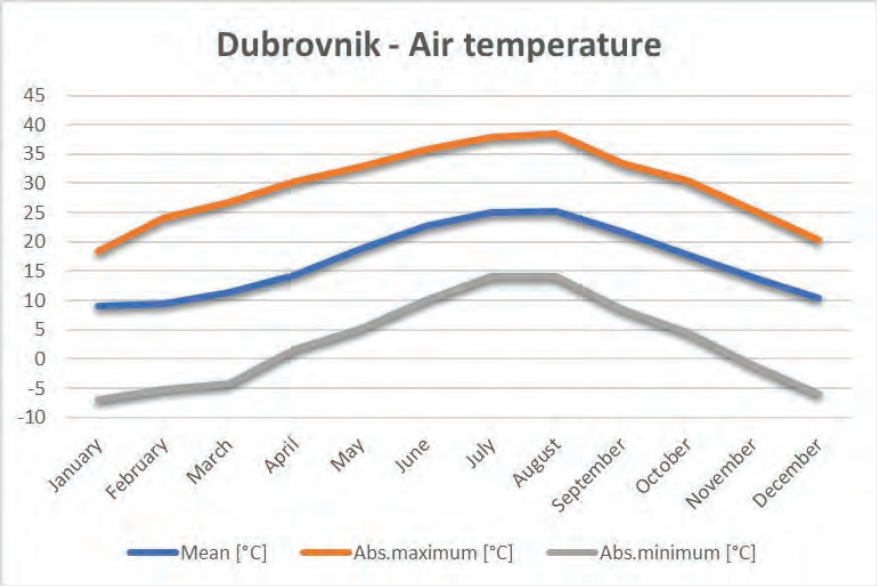


Figure 2.2 Monthly values and extremes of air temperature for Dubrovnik in 1961-2018 period (Source: CMHS)

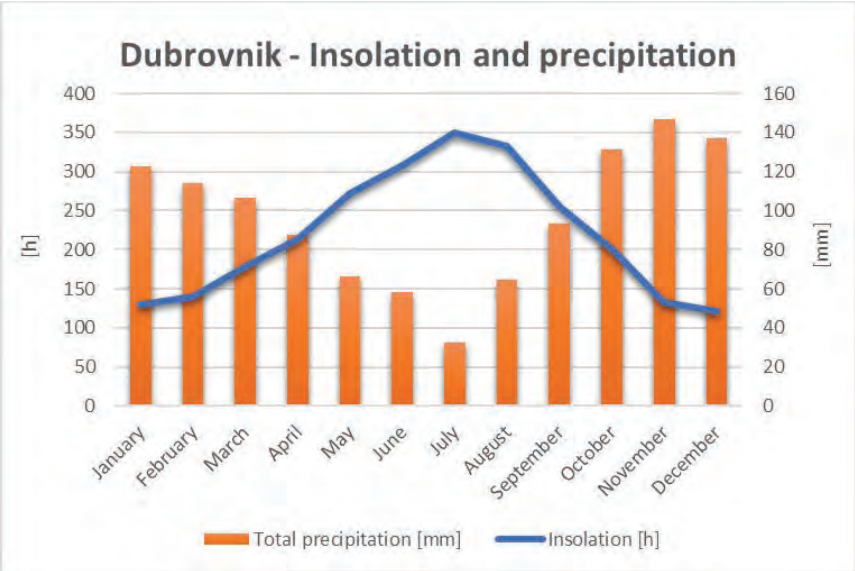


Figure 2.3 Monthly values and extremes of insolation and precipitation for Dubrovnik in 1961-2018 period (Source: CMHS)

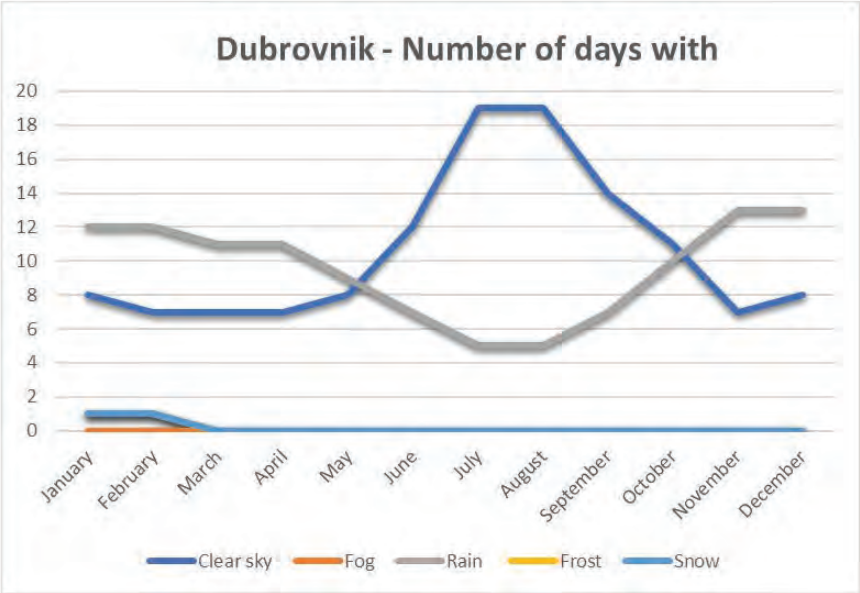


Figure 2.4 Number of days with clear sky, fog, rain, frost and snow for Dubrovnik in 1961-2018 period (Source: DHMZ)

2.1 Climate change in the City of Dubrovnik

Climate change is one of the biggest problems of the 21st century. The effects of climate change are manifested by rising air temperatures, changes in rainfall, extreme climatic conditions, as well as rising average sea level and ocean temperatures, and changing river flows. In addition to the inevitable impact on ecosystems, biodiversity and human health, climate change also has a major impact on economic sectors, often with significant economic consequences.

Information on the mean air temperature increase, as one of the most important climate indicators, has been downloaded from the official website of the CMHS. The following figure shows the mean annual air temperature (Figure 2.5) in the City for the period 2014-2018 compared to the perennial average (1961-1990). From the above it is evident that according to the percentile distribution, the thermal conditions in the mentioned period in the County were described by the dominant category as extremely warm, and an insight into the CMHS websites shows that the same trend has been present since 2011, since when CMHS has been following climate in this way.

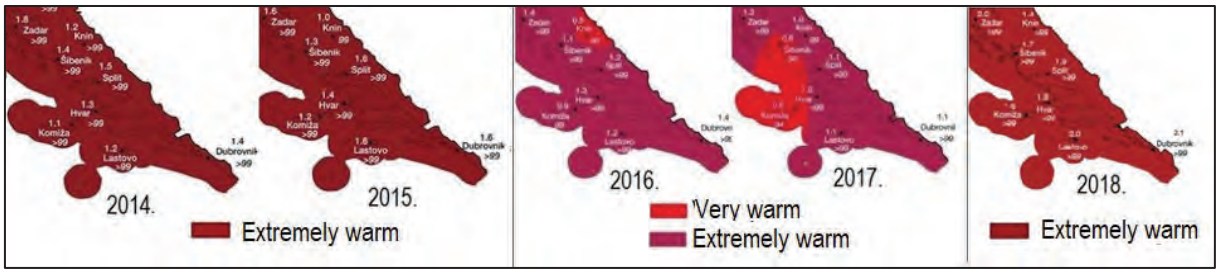


Figure 2.5 Deviation of mean air temperature in 2014-2018 in the coastal Croatia (Source: CMHS)

The Fifth National Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change emphasizes that the impact of rising sea levels could potentially be one of the most serious and costly consequences of climate change for the Republic of Croatia. The document Cost of Sea Level Rise for the Republic of Croatia, including Costs and Benefits of Adaptation, states that the City of Dubrovnik has been recognized as a particularly vulnerable zone.

3 Existing local and national documents and projects on local and national level

In the Republic of Croatia, the basic regulation on climate change is the Air Protection Act (O.G. 130/11, 47/14, 61/17, 118/18), which defines, among other things, jurisdiction, responsibility and measures to mitigate climate change and adapt to climate change. In addition to national regulations, the Republic of Croatia is also involved in international activities to mitigate climate change through the implementation of international treaty obligations - the United Nations Framework Convention on Climate Change (UNFCC Convention) and the Kyoto Protocol. In order to achieve the goals and implement the measures prescribed in these documents as effectively as possible, the legal framework for the implementation of climate change legislation has been established.

At the time of writing this Plan, the Strategy for Climate Change Adaptation for the Republic of Croatia with the Action Plan for Climate Change Adaptation, whose adoption is prescribed by the Air Protection Act, is under development. The strategy will set goals and priorities for implementing climate change adaptation measures in the Republic of Croatia. The Action Plan, developed within the framework of the aforementioned Strategy, elaborates measures and activities, timeframes for implementation, necessary funds, sources of funding, stakeholders and co-operators of the activities, over a five-years period.

Documents directly or indirectly related to climate change, developed and implemented at different government levels, currently in force in the City of Dubrovnik are listed in the following table (Table 3.1):

Table 3.1 Documents directly or indirectly related to climate change currently in force in the City of Dubrovnik

	Decisionmaker	DD/Month /YYYY *of implementation*	Name	Relation with CC	Type of document	Condition
1	City of Dubrovnik	10 September 2018	Environmental protection program of Dubrovnik City	Document includes measures for prevention, mitigation and adaptation to climate change	Program	Obligatory
2	City of Dubrovnik	19 and 21 December 2016	Program for Air Protection, Ozone Layer and Mitigation of Climate Change for Dubrovnik City 2016.-2020.	Document includes measures for prevention, mitigation and adaptation to climate change	Program	Obligatory
3	Dubrovnik-Neretva County	15 March 2017	Program for Air Protection, Ozone Layer and Mitigation of Climate Change for Dubrovnik-Neretva County 2017.-2020.	Document includes measures for prevention, mitigation and adaptation to climate change	Program	Obligatory
4	City of Dubrovnik	Written in 2017, but not adopted	The Sustainable	The plan contains measures that encourage	Plan	Voluntary

			Energy and Climate Action Plan of Dubrovnik City	efficient use of energy and the use of renewable energy sources, thus contributing to climate change mitigation and adaptation		
5	City of Dubrovnik	July 2018	Strategic plan of the City of Dubrovnik 2018.-2020.	Strategic plan contains measures to improve water management, communal and transport infrastructure contributing to climate change adaptation	Plan	Voluntary
6	City of Dubrovnik	17 May 2018	City of Dubrovnik waste management plan	Efficient waste management to reduce pollutant emissions into the air	Plan	Obligatory

Dubrovnik Development Agency, in an effort to adapt and mitigate climate change, is also involved in numerous projects such as:

➢ SOLEZ project - Smart Solutions supporting Low Emission Zones and other low-carbon mobility policies in EU cities. The Solez project brings together cities which endeavour to implement measures to support low emission zones or other low-carbon mobility policies. The project activities will lead to:

- enhanced dialogue with key stakeholders about access restriction policies through definition and implementation of proper participatory strategies,
- design, development and pilot application of innovative ICT-based services and solutions supporting low-emission zones and other access restriction policies, by contributing to reduce the negative side effect of these interventions.

➢ COASTENERGY- Blue Energy in Ports and Coastal Urban Areas

The aim of this project is to analyse, evaluate and promote energy potential and infrastructure in ports and coastal areas in the Mediterranean in order to facilitate business investment for businesses, organizations and other stakeholders, which will primarily focus on thermal energy and wave energy. The initiatives will guarantee the sustainable development and conservation of the marine and terrestrial ecosystems and will be in line with other activities in the Mediterranean coastal area such as fishing, tourism and the maritime industry.

➢ SEADRION - The recent Heating and Cooling Strategy from the European Commission indicated that emissions related to energy used for heating and cooling of buildings can be significantly reduced with technologies which use renewable energy sources and have high efficiency. Taking this into consideration the SEADRION project aims to support the development of a regional innovation system for the Adriatic-Ionian area with the installation of 3 renewable energy facilities in the public buildings located in Greece and western and south part of Adriatic Croatia.

- LAirA (Landside Airport Accessibility)

The project aims to reduce energy use and environmental impacts of transport activities by changing mobility behaviours of airport passengers and employees and by creating novel strategies in low carbon mobility planning for local authorities.

4 Selection of the impacts

4.1 Summary of the process that led to the selection of the most relevant CC impacts

In order to develop an appropriate analysis for each of the locations, it was decided, in agreement with all partners to focus on 4 main climate change impacts (and related hazards) identified as the most relevant for the pilot areas.

The detection of the hazards and the potential impacts is based on two phases:

a) identification of a broader group of hazards and climate change impacts;
b) the selection of a narrower set of hazards and impacts that are considered to be more relevant for the pilot areas based on local expert's knowledge.

Hazards that contribute to climate change impacts that have been considered in this project are:

- increasing temperature;
- decreasing temperature;
- increasing extreme atmospheric events;
- increasing windstorms;
- increasing precipitations;
- decreasing precipitations;
- sea level rise.

Each of these hazards, singularly or jointly, are considered to effect in different ways and with different intensity on certain macro-areas or sectors. Macro-areas that can be affected by climate change and that have been considered in this project are:

- agriculture;
- ecosystem & environment;
- energy; coastal areas;
- hydrology & water resources;
- socio-economic.

For each sector, a set of impacts considered more relevant for the Adriatic Region have been identified. Table below (Table 4.1) shows the list of impacts presented to the PP and from which the PPs have selected those that they consider to be most relevant for their area.

Table 4.1 First list of climate change impacts from which the PPs are asked to choose

Sector	Impacts
Agriculture	Variation in crop yield
	Variation in livestock production
	Increased irrigation demand
Hydrology and water resources	Increase of drought
	Increase of flooding
	Increased competition for water
	Increase of urban flooding
Coasts	Increased erosion
	Coastal flooding
	Damage to coastal human infrastructures
	Damage to coastal natural environments
Energy	Impacts on energy infrastructures (energy plants, etc)
	Increased energy demand for cooling
Socio-economic	Increased Urban Heat Island effect
	Impacts on weakest group of people
	Impacts on commercial activities
	Impacts on public services
	Impacts on industrial activities
	Impacts on transportation network
	Impacts on tourism sector
Ecosystems and environment	Loss of species
	Loss of habitat
	Increased forest fires
	Increase of invasive species and parasites

Table 4.2 Impacts selected by the PP as most significant for the Dubrovnik area

PP	Climate Change Impact			
DURA	Increased erosion	Increased energy demand for cooling	Impact on tourism sector	Impact on transportation network

4.2 Summary and description of decision-makers and stakeholders identified

The overall objective of the iDEAL project is to integrate environmental-climate observations with socio-economic issues, in order to allow decision-makers (end-users) to evaluate several adaptation alternatives in order to create a robust climate adaptation plan.

In order to have a clear vision of what is the governance system for each project area, it has been proposed an interview module that each PP spread through its network. Hazards, macro-areas and specific impacts have been organized in the format of a questionnaire. The interview has been than submitted to local experts for each pilot areas. The Fac-Simile reported below demonstrates the main interview questions (Figure 4.1). The document has been divided into two parts, the one dedicated to stakeholders and the other to decision makers. The differences between the questions posed to the one category and the other are related to the need of identifying the field of interest of each subject and in which way it is linked to the others. Moreover, the interviewees were asked to describe also their inner resources and the main hazard/impact that they consider to be related to their activity.

STAKEHOLDERS	
Now considering the hazard and the impact selected before who are the possible *stakeholders*?	
Name/Organization	
Interests	
Relations with others	
Resource description	_
Hazard/impact	
DECISION-MAKERS	
Now considering the hazard and the impact selected before who are the possible decision-makers?	
First Name	
Last Name	
Office/Authority	
Position/role	
Power description	
Resource description	_
Hazard/impact	

Figure 4.1 Sample questionnaire posed to stakeholders and decision makers

Decision-Makers

In our context the decision-makers are all subjects that can take or affect a decision. It means that we consider as decision-makers not only the major of the Municipality, but also all the people that can drop or hinder the final decision or its implementation. The decision-makers change with every decision. Thus, could be a decision-makers: the major, municipal council, regions, provinces, other specific authorities, etc

- City of Dubrovnik – Major

- Executive authority of the city of Dubrovnik, limited to the city limits only. Major is recognized to have political, social, and normative influence and for being the executive authority for the city of Dubrovnik.

- City of Dubrovnik - City Council

- Comprised of 25 civic members. Councillors are in charge of a legal framework of the city of Dubrovnik and have social, political power to influence groups of people as they represent citizens of Dubrovnik.

- Dubrovnik Neretva County – County governor

- The complete authority over the county, but not the city itself. County governor has a social, political, and normative influence towards making decisions.

Stakeholders

In our context the stakeholders are all the subjects or group of people that can influence in some way the decision or that can condition/press the decision-makers. It means that we consider as stakeholders all those who directly or indirectly can be affected by the decision itself, all those who have relevant information and all those who have some interest in the decision (whether it is taken or rejected). The stakeholders change with every decision.

- City of Dubrovnik/Department for Urbanism, Spatial Planning and the Environment

- This administrative department, as a stakeholder, has the political resource to influence initiative/action or work. Interests of this department are professional activities related to drafting and executing draft proposals for spatial planning and environmental safety. Department for Urbanism, Spatial Planning and Environmental Protection participates in the monitoring of work and cooperation with institutions, City of Dubrovnik and Dubrovnik-Neretva County

- City of Dubrovnik/Department for Licensing and Issuing Documents for Spatial Planning and Construction

- This administrative department has the ability to influence the project in a normative or political level. Assignment of this department is to issuing construction licenses/drafting proposals for the spatial development of the City of Dubrovnik. This is the department within the City administration that performs activities in the field of spatial planning and is focused toward solving administrative issues regarding local permits and construction legalization.

- City of Dubrovnik Department for Traffic

- Administrative department under the city administration with its aim to regulate road transportation. This administrative department is recognized to have political, social and normative resources for cooperating under the state transportation system.

- Dubrovnik Neretva County

- Dubrovnik Neretva County has the economic, social, and normative resources that are further divided into 5 cities and 17 municipalities. Assignment of this department is the development of projects and monitoring their progress in conjunction with 5 cities and 17 municipalities with the aim to improve conditions for their citizens and communities.

- University of Dubrovnik

- The University of Dubrovnik is recognized to have social resources - the ability to influence opinions of a larger group of people through activities and programs for higher education and scientific work in the fields of maritime, social and natural sciences. The division of seven departments, in cooperation with Public Institutions and international activities, aims to improve scientific research.

- Dubrovnik Port Authority

- Dubrovnik Port Authority is recognized to have normative resources due to its port administration being a legal representative of the State. The Port Authority is founded to govern, construct and use the Port of Dubrovnik in cooperation with the Croatian legal/public entities.

- Vodovod Dubrovnik Ltd. (Water Supply)

- Water supply company is recognized to have economic resources which can be supportive of new initiatives. Vodovod Dubrovnik Ltd. has interests in activities concerning water supply and communal hydro projects, and waste treatment plan. This company covers three municipalities and the City of Dubrovnik and it is managing projects co-financed by EU funds and local Public Institutions to increase the quality of water supply and waste management.

- Čistoća Dubrovnik (Cleaning/Waste Management)

- Čistoća Dubrovnik as a stakeholder has ability of economic influence for or against any given project. Assignment of this department is managing projects with Public Institutions and other companies with the aim to introduce new technological solutions for waste management.

- Croatian Institute for Public Health

Central public health institute that cooperates with different public institutions and universities to promote education, health, and welfare of the population. Their main task is the promotion of health and welfare of the population/education/disease prevention/environmental health.

- NGO Bonsai

- NGO Bonsai promotes active civic participation through volunteering, education, and creative development for the common good. It has the ability to influence initiatives/work on a social level for being involved in the promotion of citizen participation.

- Elektrojug Dubrovnik Ltd.

- Elektrojug is company under the HEP group that has 21 distribution areas across Croatia. A large amount of SECAP support was provided by HEP, which provided all the required data on energy consumption for the City of Dubrovnik. Elektrojug (under the HEP group), as a stakeholder, has the ability to influence initiatives/projects on an economic level.

- Faculty of Mechanical Engineering and Naval Architecture

- Faculty of Mechanical Engineering and Naval Architecture carries out activities and programs for higher education and scientific work in the fields of Mechanical Engineering and Naval Architecture. The University has the potential of economic or social influence over a given initiative/project as a result of their scientific research and its impact.

- The Department of Environmental Protection and Nature of Dubrovnik-Neretva County

- Administrative department under the County administration that monitors implementation of regulations and cooperates with the Public Institutions in the field of environment and nature protection. This administrative department, as a stakeholder, is recognized to have political and social resources for any given project/initiative.

The mapping process of decision-makers and stakeholder resulted in the map reported below (Figure 4.2), where hierarchy of governance is demonstrated. The governance map is used to describe the hierarchy of the governance system of each territory, and it is used inside this assessment to identify decisionmakers and stakeholders who have been asked to answer the questionnaires.

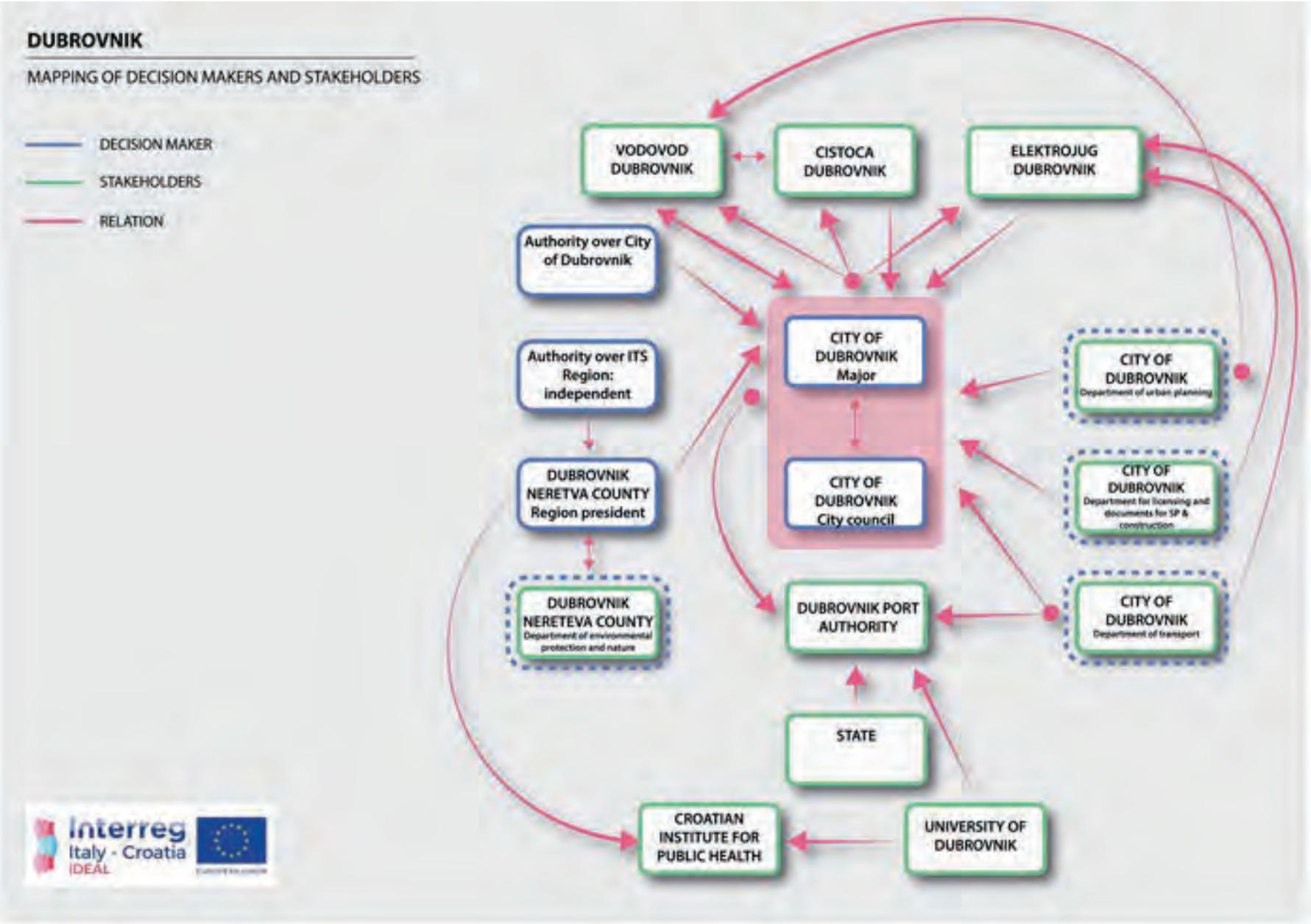


Figure 4.2 Dubrovnik – Governance map

4.3 Results of the interviews and questionnaires

Answers on interviews come from stakeholders who delivered 25 answers or 65 % and from decisionmakers who delivered 6 answers or 35 % (Figure 4.3).

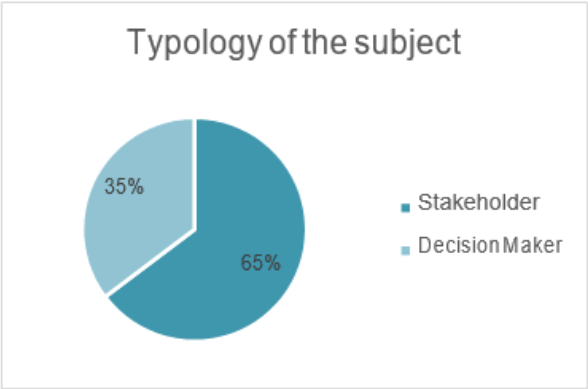


Figure 4.3 Typology of the subject

We will observe that decisionmakers and stakeholders will answer (Figure 4.4), with minimal differences of percentage and quantity, mostly in the same way, except for “Collaboration with others”, where “yes” is inverted with “no”, and Knowledge level (decisionmakers have, in discontent order average, good and excellent level) and stakeholders have in increasing order average and good level.

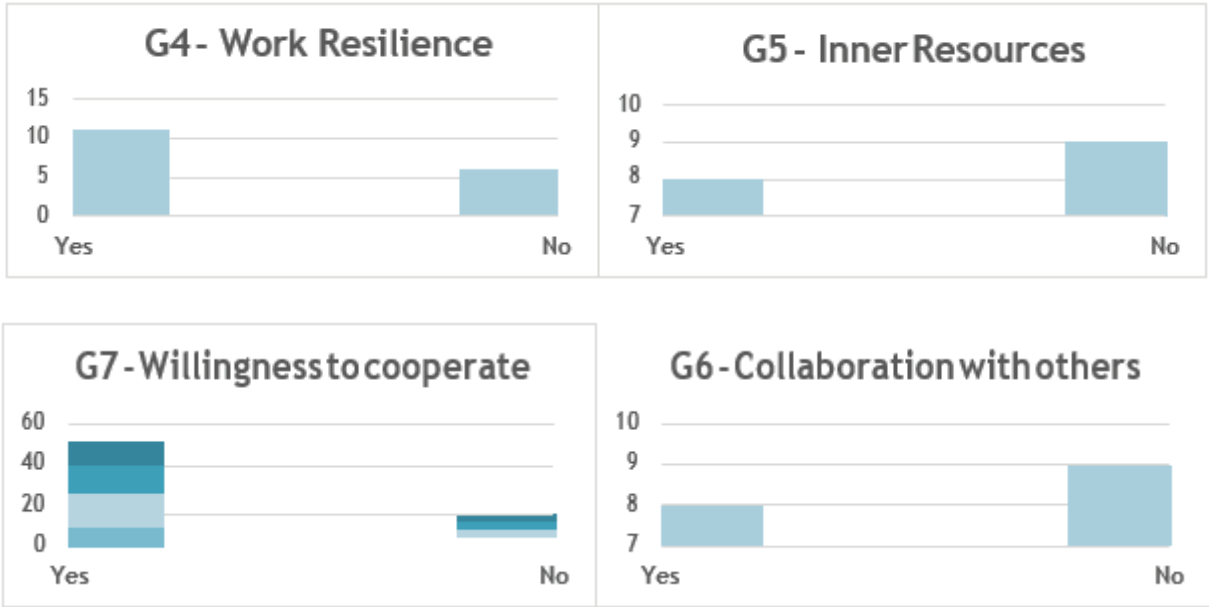


Figure 4.4 Dubrovnik's answers on interviews from the Stakeholders and Decisionmakers

Local experts have been asked to complete the questionnaire by which the four impacts selected by the PP (Table 4.2) should be ranked by relevance for their area, also linking each selected impact to the most relevant hazards.

The general impact importance (Figure 4.5) is mostly homogeneous, with on the top "Increased energy demand for cooling" (1380), then "Impact on transportation network" (1100) and "Impact on tourism sector" (980), and finally "Increased erosion" (880).

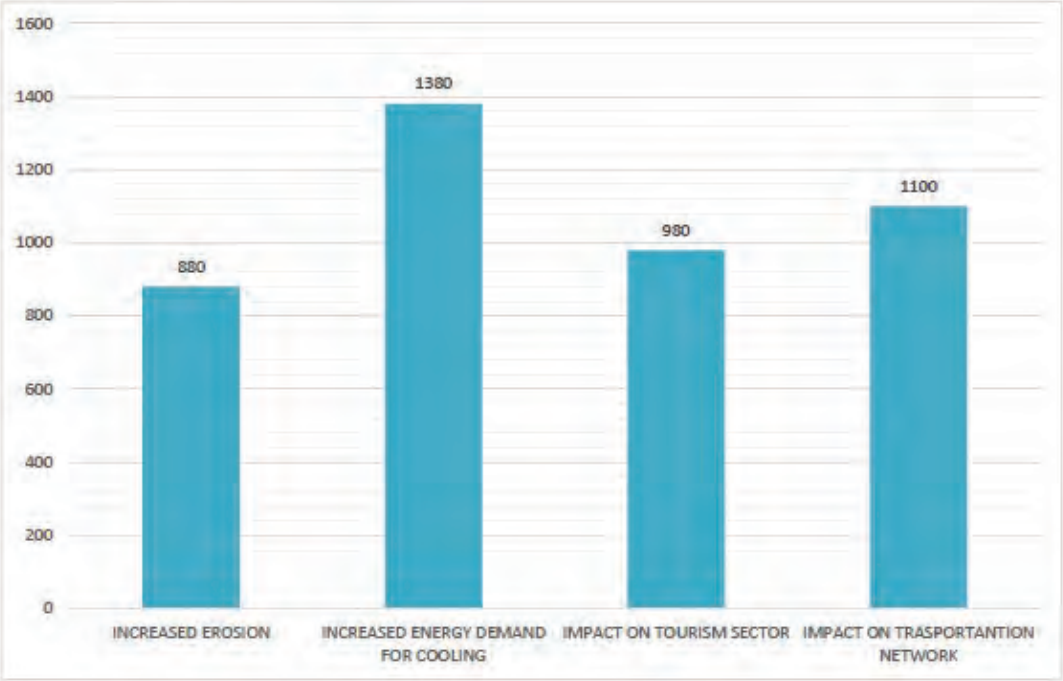


Figure 4.5 General selection of the impacts by the stakeholders and decision makers

The following figure (Figure 4.6) shows how decision makers and stakeholders have selected indicators that are related to impacts in their area. The most important indicators are those from the environmental group, then social, economic and legislative / institutional.

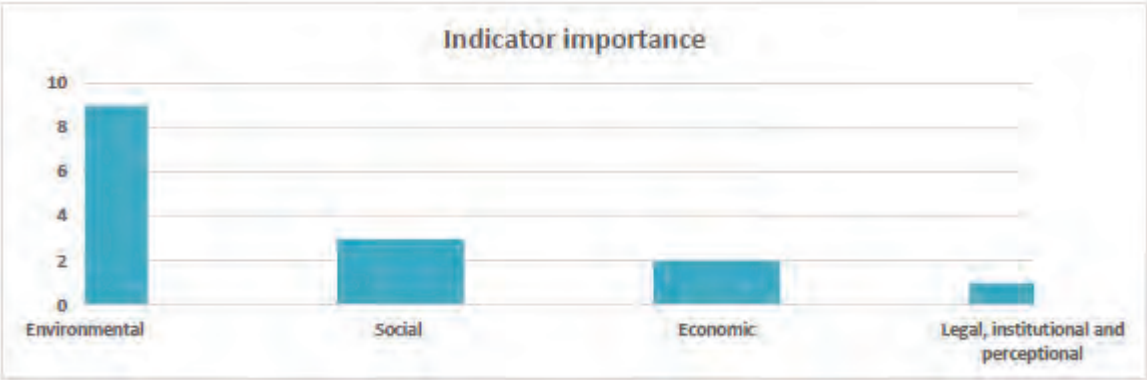


Figure 4.6 General selection of the indicators by the stakeholders and decision makers

5 Methodology

5.1 Methodology and the data sheets

The methodology for the assessment of the climate vulnerability is based on a three-steps process (Figure 5.1):

1) the definition of the most relevant hazards and climate change impacts;
2) the selection and collection of a dataset for each pilot area;
3) the development of the vulnerability assessment.

Figure 5.1 Workflow in 3 steps

In order to develop an appropriate analysis for each of the locations, it was decided, in agreement with all partners, to focus on 4 main climate change impacts (and related hazards) identified as the most relevant for the pilot areas. In this project, "hazards" and "impacts" are defined, according to IPCC 5th report (IPCC, 2014), as follow.

Hazards: the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate- related physical events or trends or their physical impacts.

Impacts: effects on natural and human systems. In this report, the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

Based on the results from the first round of climate change impacts identification, the methodology of data selection and collection activities were initiated. All Project Partners (PPs) were asked to provide data and information that were considered necessary in order to proceed with the development of the risk and vulnerability assessment.

Data and information requested were specific for each area and they were a consequence of the impacts identified. Data requested to each partner, vary from climate data (e.g. historical series of precipitation and temperature), to cartographic data to be used in GIS environment (e.g. shape files of buildings, transport networks, land use, hydrology, etc.). The vulnerability assessment is meant to be based in a GIS environment in which vulnerability is geographically spatialized and visible in a set of maps. However, this is not possible for those impacts that could not be linked to specific geographic areas.

The bulk of data and information that were initially considered useful for the analysis and that were therefore requested from the PPs were:

- DSM (Digital Surface Model) and/or
- DTM (Digital Terrain Model) (raster)
- Land Cover (.SHP)
- Land Use (.SHP)
- Protected Areas, ZPS, SIC (.SHP)
- Soil Type and geological map (.SHP)
- Administrative unit boundaries (.SHP)
- Population census data (.SHP, DATA)
- Buildings and infrastructures (street and railway, etc.) (.SHP)
- Slow mobility network
- Hydrology map (.SHP)
- Beach Nourishment Plan (.SHP, DATA)
- Cadastral data (commercial tourism activities, residential etc.) (.SHP)
- Cultural and Natural Heritage
- Tourist numbers data
- Tourist infrastructures and buildings (.SHP)
- Water consumption by sector (as detailed as possible)
- Energy Performance Certificate for Building
- Agriculture typology map
- Daily Precipitation and temperature data 1990 – 2017

The differences between the pilot areas in terms of interests expressed by local experts/decision-makers and quality/quantity of data availability have made it necessary to adopt a flexible working methodology. The methodology is based on the same main principles and step-by-step process in all pilot areas, but it is then adapted according to the specific situations and challenges to be tackled in each case.

After this phase of data selection and collection some first challenges emerged particularly in the case of the Croatian pilot areas. In some cases, data required were not available in GIS file format or they were not available at all. Because the difficulties in aggregating data at the census level for the Dubrovnik area, a hexagonal grid was prepared. The hexagons (160 m each side and an area of 66 510,75 m^2) were used as geographical unit of analysis. Due to the lack of data, a thorough risk and vulnerability assessment was not possible for Dubrovnik pilot area. It was therefore decided, in agreement with PPs, to focus on the analysis of phenomena such as “Urban Heat Island”, “Urban Flooding” and “Sea-Level Rise”. In these cases, it was possible to carry out qualitative assessments relying on open data. The analysis was carried out on urban areas exclusively.

The ultimate impacts selected for Dubrovnik pilot area are summarized in the table below (Table 5.1).

Table 5.1 Ultimate list of impacts for Dubrovnik pilot area

Pilot area	Impacts
Dubrovnik	Urban heat Island
	Urban flooding
	Sea level rise

The final phase is specifically oriented to vulnerability and risk assessment related to impacts identified in the first phase. The first section is dedicated to the development of two general indicators, namely “Land Surface Temperature - LST” and “Vegetated Surfaces - VS”, that are used to build more specific indicators according to the impact to be assessed. Both LST and VS contribute to define vulnerability (as sensitivity or adaptive capacity) for impacts such as “energy demand for cooling”, “urban heat island”, “impacts on tourism sector”, etc.

Urban Heat Island (UHI)

Urban heat island (UHI) is a micro-climatic phenomenon that occurs within urban areas and that consist in higher temperature in artificial built-up areas compared to, for example, rural surroundings or green areas (Oke, 1982). Understanding the areas in which UHI might be more pronounced can help to identify areas subjected to impact on economic activities, energy consumptions, health, habitat, etc.

Impermeable surfaces (% within the hexagon) and Land Surface Temperature (average value within the hexagon) constitute the Sensitivity indicator. Whereas building area within the hexagon represents the exposure value. Adaptive capacity is represented by the Vegetated surface within each hexagon.

$$S = \frac{\frac{Is}{Ahx} + LST}{2}$$

$$E = \frac{Ab}{Ahx}$$

$$AC = \frac{Vs}{Ahx}$$

Where:
Ab: Buildings area within the hexagon
Is: Impermeable surfaces within the hexagon
LST: Land Surface Temperature (Average value within the hexagon)

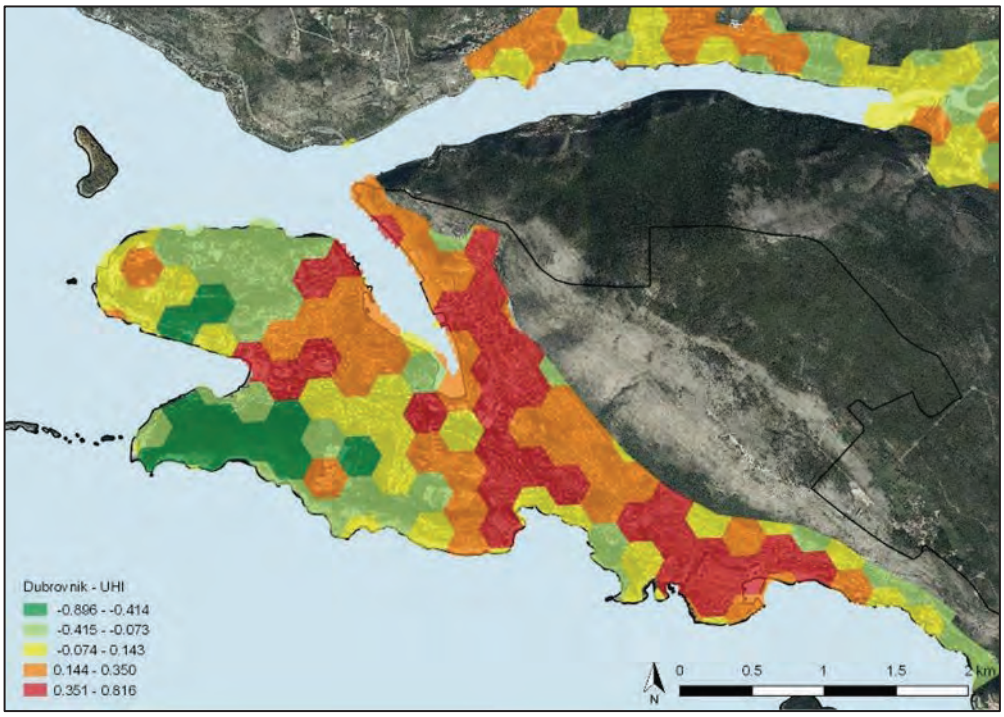


Figure 5.2 Urban Heat Island Risk Map – Dubrovnik

Urban Flooding (UF)

Urban floods - are the result of human interventions in the area and most often occur during short-term and intense rainfall, when surface runoff exceeds the drainage capacity of the sewerage system due to rapid inflow from roofs and asphalt surfaces.

Urban flooding has been evaluated considering the presence of more constructed areas since natural runoff is disadvantaged by the concentration of impermeable surfaces referable to infrastructures or buildings.

Through remote sensing indices applied to a multiband satellite image (Landsat 8), it was possible to determine the presence of vegetation and built using the corresponding NDVI (Normalized Difference Vegetation Index) and NDBI (Normalized Difference Built-up Index).

Subtracting NDBI-NDVI, the most permeable areas will be excluded, obtaining a mapping of the most constructed areas (Zha, 2003) and therefore more critical in the event of flooding.

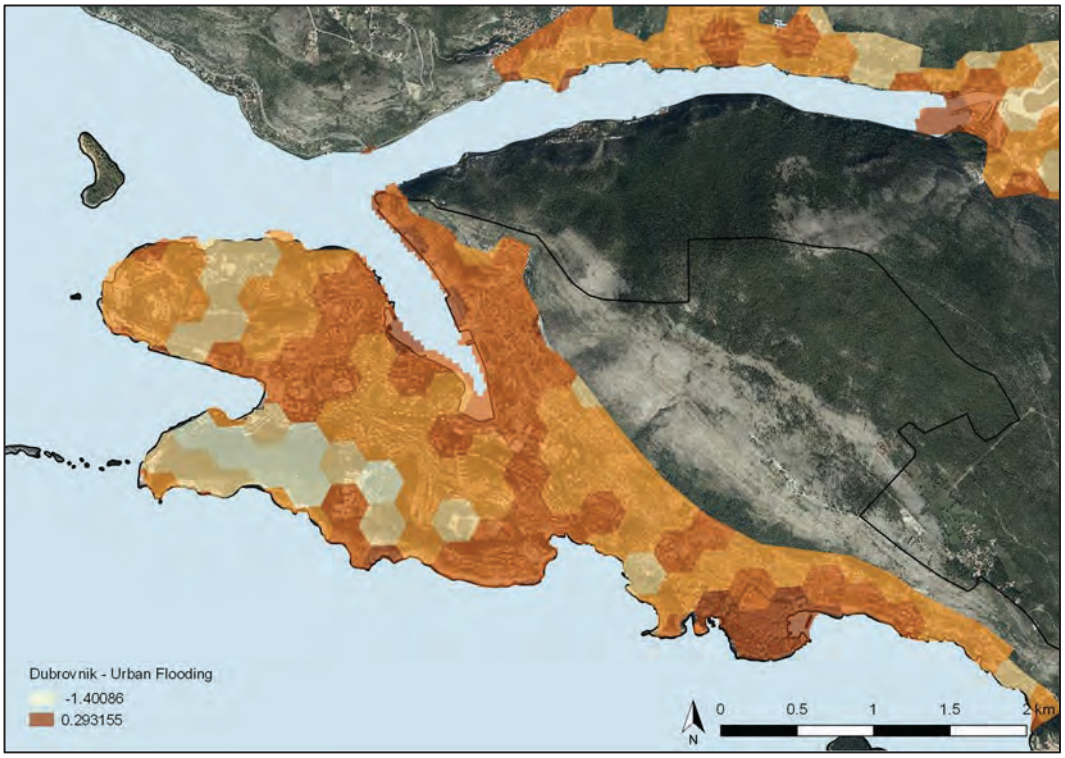


Figure 5.3 Urban Flooding Risk Map – Dubrovnik

Sea Level Rise (SLR)

A scenario involving 1 m sea-level rise due to climate change was here considered. In order to identify those areas that might be affected by such a phenomenon, the SRTM Digital Terrain Model (30 m resolution) was downloaded from the United States Geological Survey website. Areas with less than 1m elevation were identified in GIS environment, and then the percentage of surfaces <1m within each hexagon area was calculated. Figure below (Figure 5.4) identifies those areas in the pilot areas that might be affected in a 1m sea-level rise scenario.

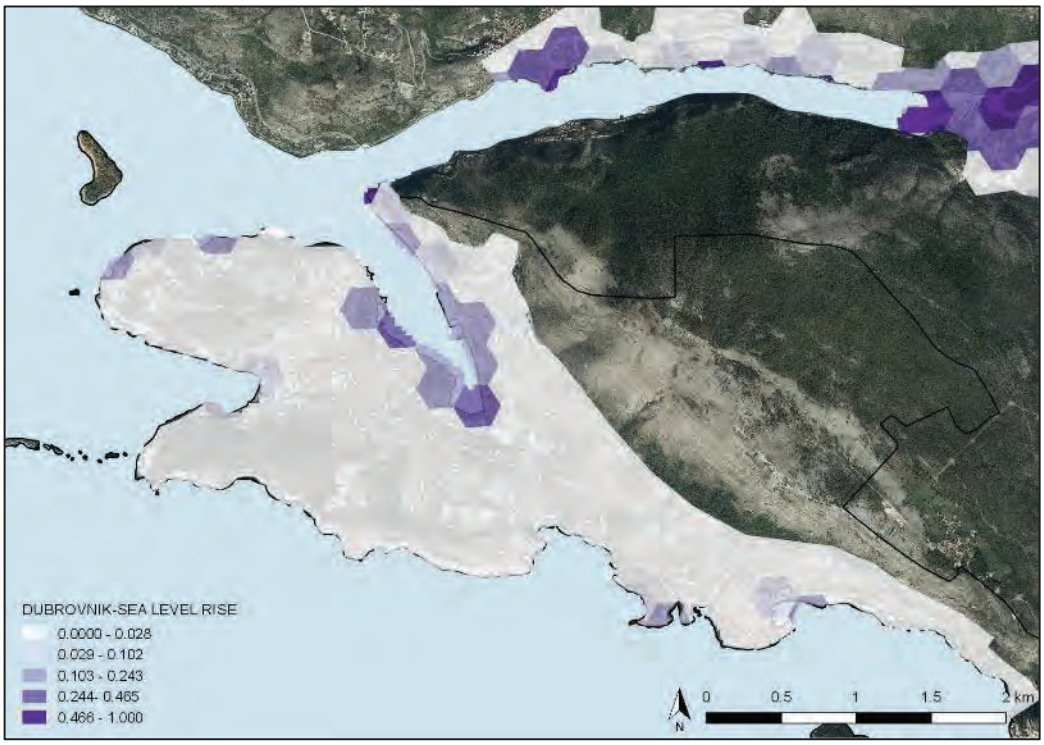


Figure 5.4 Areas impacted by Sea Level Rise – Dubrovnik (Source: IUAV)

The climate vulnerability and risk analysis are the first step to raise awareness and improve knowledge about climate change impacts in the pilot area. The kind of information provided through the vulnerability and risk analysis is a fundamental component for the design of the climate adaptation plans.

5.2 Indicators for action evaluation (DSS)

Determining the effects of climate change in a specific region using a scientific approach is necessary to develop a sound set of objectives, strategies, and actions. The approach consists of identifying the hazards in order to develop a model where the threats are clearly defined.

A double quantitative evaluation follows, where the first one observes the hazard itself and it's defined as "impact", while the second one regards the territory exposure to the phenomenon, and it's defined as "vulnerability". Linking the vulnerable object and the threat, quantitatively, requires the unit of measurement through which to express the equation of this relationship. What can join the impacts and the vulnerability are the indicators.

From the indicators presented in the project TERRE, 28 of them were selected (Table 5.2) to describe the territories and necessities of each Project Partner. The evaluation of each indicator was made in relationship with the tailored impacts selected by each PP.

Thus, through the interviews proposed to stakeholders and decisionmakers, a further weighing has been made with the purpose to adjust the DSS. This elaboration will allow the project partner to use their tailored decision support system to analyse the validity - and the performances - of the adaptation measures that they would use to cope with the climate change effects.

Table 5.2 The list of indicators for action evaluation

Aspect	Indicator	Unit of measurement
A. Environmental	*Soil coastal erosion*	*m^2*
	Soil drought	*m^2*
	Impermeability ratio	*m^2*
	Flooding area	*m^2*
	Collected rainwater	*m^3/year*
	Reused water	*m^3/year*
	Water consumption	*m^3/year*
	Habitat maintenance	*m^2*
	Uhi reduction	*c°*
	Energy use reduction	*%*
B. Social	*People who will benefit from the actions (n. Of people)*	*n. Of people*
	Most vulnerable people who will benefit from the actions	*n. Of people*
	New job created by the actions	*n. Of job*
	Km - upgraded infrastructure	*km*
	New infrastructure	*km*
C. Economic	*Implementation cost*	*€*
	Management cost	*€*
	Revenues	*€*
	Revenues distribution	*n. of actors*
	Enterprises supported	*n. of enterprises*
	New enterprises	*n. of enterprises*
	Traditional crops	*ton/year*
	Legal feasibility	*low-medium-high*
	Required permits	*n. of permits*

D. Legal, institutional and perceptional	*Procedural time*	*days*
	Lifetime	*days*
	People acceptability	*low-medium-high*
	Political acceptability	*low-medium-high*

With regard to the availability and quality of data, a total of 6 indicators were selected to evaluate the actions proposed by this Plan:

- Flooding area,
- Uhi reduction,
- Energy use reduction,
- People who will benefit from the actions n. of people,
- People acceptability,
- Political acceptability.

Climate change has a direct impact on human health through climate variability and extreme weather, and indirectly affects the availability, quantity and / or quality of drinking water, food and air, as well as negative changes in particular ecosystems and infrastructure that are important for the quality of life. The warmer and wetter conditions predicted by climate scenarios may favour the spread of food or water-borne diseases such as diarrhea and dysentery. Due to all of the above, the indicator “People who will benefit from the actions n. of people” has been used to assess the impact of the proposed actions on the population.

Effects related to the development of UHI represent one of the most significant environmental problems in cities because they are associated with multiple negative consequences, such as overheating of the substrate, adverse climatic conditions to which citizens are exposed, increased health risk due to high temperatures, increased need for water, increased energy consumption, etc. In order to evaluate the impact of a particular action on the heat island mitigation in the City, the “Uhi reduction indicator” was selected.

As the vulnerability analysis has shown, the City of Dubrovnik is vulnerable to urban floods and sea level rise, therefore the “Flooding area” indicator is selected for the evaluation of the proposed measures. The coast and coastal area are in particular strategically important natural and economic resource of the City of Dubrovnik. In the context of the impact of climate change on the coast and coastal areas, the greatest risk is the rise in sea level, which can lead to a series of irreversible and negative effects. Although the Croatian coast is relatively steep, the magnitude of the effects of sea level rise in the coastal area could be significant. The centres of historic coastal cities represent valuable cultural assets and are also attractive to tourists.

Energetics is one of the most vulnerable sectors when it comes to climate change, and it is especially expected that energy consumption for cooling will increase, so in our analysis the “Energy use reduction” indicator was selected. The main expected impacts caused by the vulnerability in the energy sector are: a reduction in electricity production in hydroelectric power plants due to changes in the time distribution of annual rainfall (no significant changes are projected at the annual average - with a slight reduction, but there are changes in rainy and dry periods, with an increasing trend of droughts), an increase in electricity consumption for cooling due to an increase in mean air temperature, a decrease in energy production in thermal power plants due to insufficient cooling of plants due to a decrease in mean annual rainfall, damage to energy facilities and infrastructure due to extreme weather events, a decrease in electricity production in hydropower due to drought.

The political will to support sustainable development and adaptation to climate change is of utmost importance, so each action was evaluated against “Political acceptability” as well. Equally important is the will of the population to adopt measures or actions that will be implemented in their environment to adapt to climate change. Therefore, the

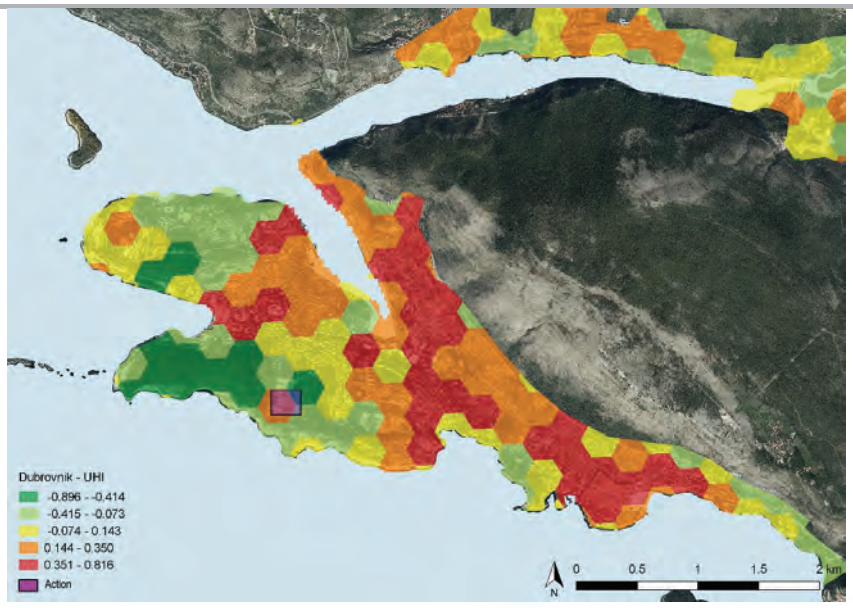
indicator “People acceptability”, which is measured as low, medium or high, represents the degree of acceptance of the adjustment measures by the population.

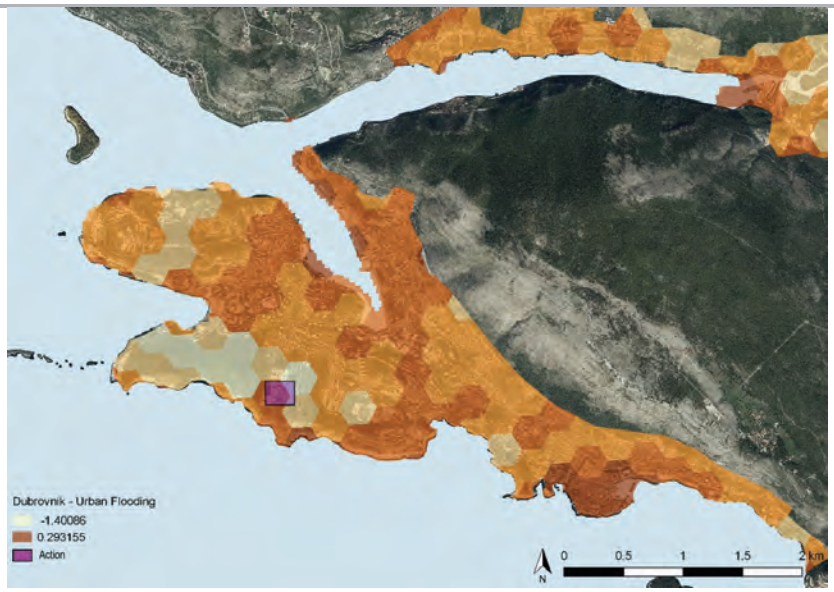
6 Actions

6.1 Development of actions packages

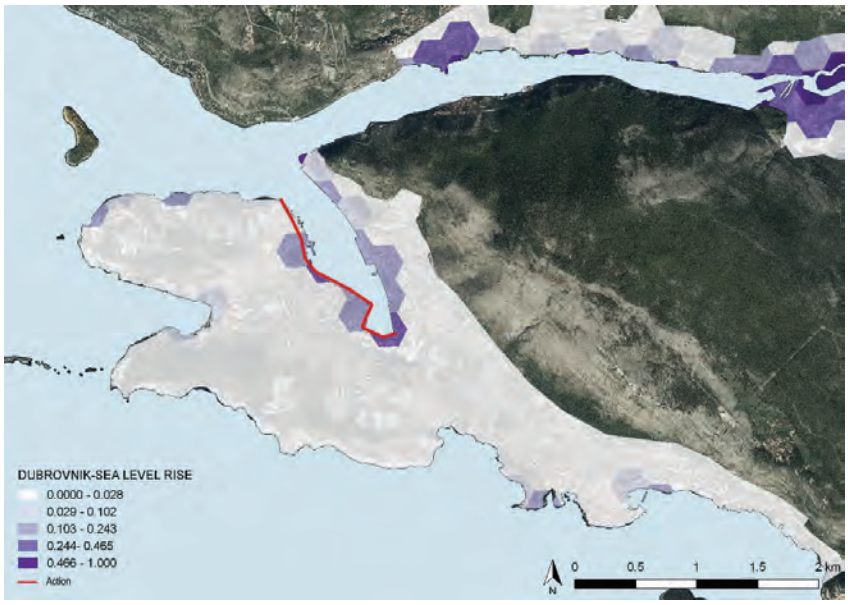
After selecting the indicators to evaluate, climate change adaptation actions were defined. A total of 12 action were defined. All actions are defined in consultation with stakeholders and decision makers in order to find the best solutions. Each action is described in detail (basic characteristics, time frame, unit of measure, funding source, geographical location, actors to be involved, etc.).

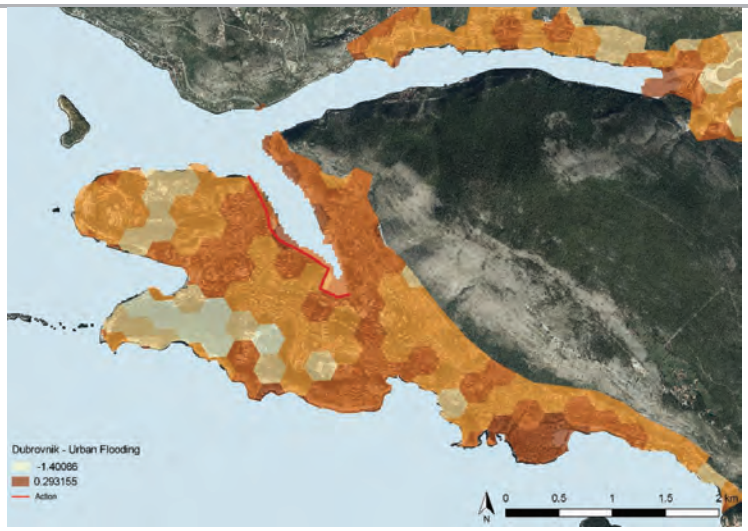
6.1.1 ACTION n°1:

TITLE	*Parking lots alteration*	ID HEXAGONS	*329*
GENERAL DESCRIPTION	*The action refers to the existing parking lot of Dubrovnik General Hospital, that will be altered into an underground garage. On the area of the existing parking lot there will be a park area. Realization of this measure will mitigate the phenomenon of the urban heat island and will create a new green oasis that will provide the shade and a place of relaxation and socialization to all citizens, patients and employees of Dubrovnik General Hospital. Furthermore, by removing the existing asphalt surface and placing green areas soil permeability will increase, which has a direct impact on reducing the risk of flooding.*		
TECHNICAL INFORMATION	*The underground garage is a permanent establishment where parking is organized in a structured manner, with defined entry and exit, with internal traffic areas and organization of traffic between planned parking spaces, and with ramps for access to the upper floors and the parking equipment. One of the advantages of underground garages is that the upper surface can be used for various purposes, in this case, for the construction of a park. Green areas fulfil many functions in the urban context that improve the quality of the urban environment and the life in the city and mitigate the impact of climate change.*		
KEYWORDS	*#UrbanHeatIsland, #UrbanFlooding, #PeopleHealth*		
LOCATION	*Address: Dr. Roka Mišetića 2, 20000, Dubrovnik* *Area: 6800 m²* *Geographic coordinates: 42°38'53.43"N, 18° 4'39.84"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			

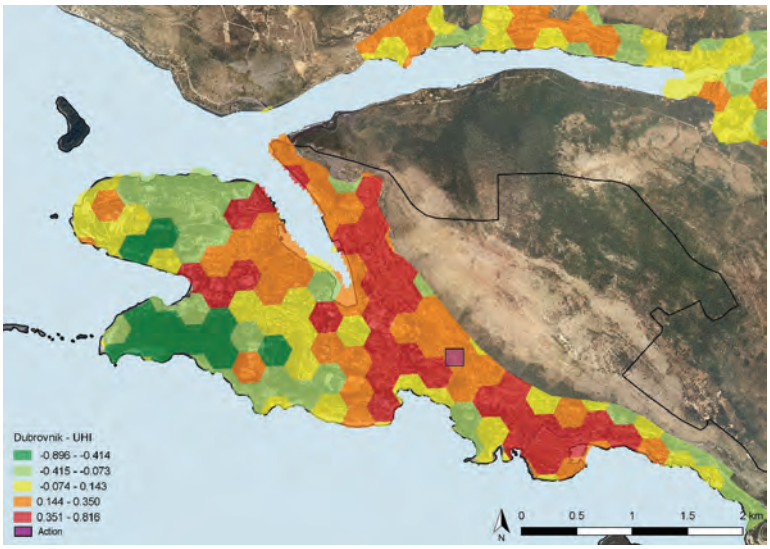
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban heat island; Urban flooding*
PROJECT INITIATOR/PROMOTER	*Dubrovnik-Neretva County*
STAKEHOLDERS INVOLVED	*Dubrovnik General Hospital, City of Dubrovnik, Ministry of Environment and Energy, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Citizens; Patients; Employees*
TIME OF START/IMPLEMENTATION	*Time of implementation: 2025.*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m^2)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 2,5°C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 12300 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 16000*

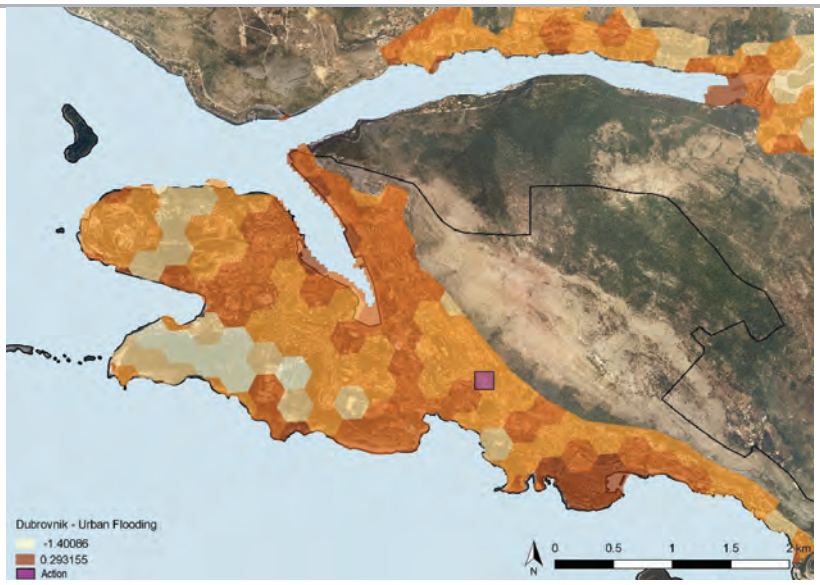
6.1.2 ACTION n° 2:

TITLE *Sea Wall*	ID HEXAGONS *451; 419; 418; 387; 355; 354*
GENERAL DESCRIPTION	*A seawall (or sea wall) is a form of coastal defence constructed where the sea, and associated coastal processes, impact directly upon the landforms of the coast. The purpose of a sea wall is to protect areas of human habitation, conservation and leisure activities from the action of tides, waves, or tsunamis. As a seawall is a static feature it will conflict with the dynamic nature of the coast and impede the exchange of sediment between land and sea.*
TECHNICAL INFORMATION	*A properly designed seawall will provide robust protection to foreshore assets and require minimal commitment to future maintenance. Here are many types of components that can be used to construct robust seawalls. There have also been many that have been tried with varying degrees of success. Historically these have included:* • *rock – either as multi-layered, rip-rap or pitching* • *concrete – as preformed reinforced or unreinforced units and slabbing* • *concrete mattresses* • *asphalt* • *gabions* *Since each has widely divergent advantages and disadvantages, the selection of an appropriate seawall type requires specialized coastal engineering advice.*
KEYWORDS	*#SeaLevelRise; #Seawall; #CoastalDefense*
LOCATION	*Geographic coordinates:* Start point: *42°39'11.9"N 18°05'17.7"E, Nikola Tesla Street, Lapadska obala Street, Ivana pl. Zajca Street (WGS 84/UTM zone 33N)* *Area: 4950 m²*
MERGE WITH VULNERABILITIES	

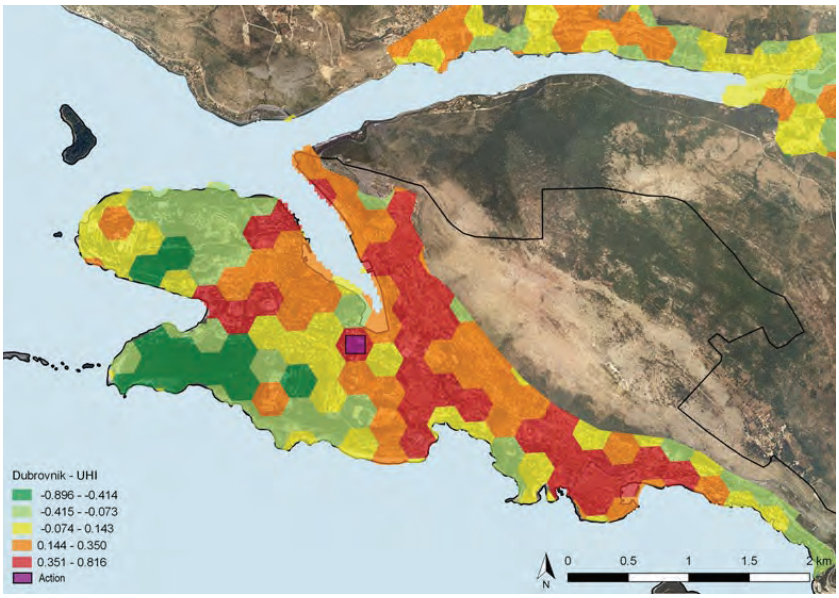
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Sea level rise; Urban flooding*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik*
STAKEHOLDERS INVOLVED	*City of Dubrovnik*, Ministry *of Environment and Energy, City of Dubrovnik Development Agency (DURA), Dubrovnik Port Authority*
BENEFICIARIES/TARGET GROUP	*Citizens, Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2040*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m^2)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0°C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 2250000 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: low* 5. *Political acceptability: low*
C-SOCIAL	6. *People who will benefit from the actions: 12000*

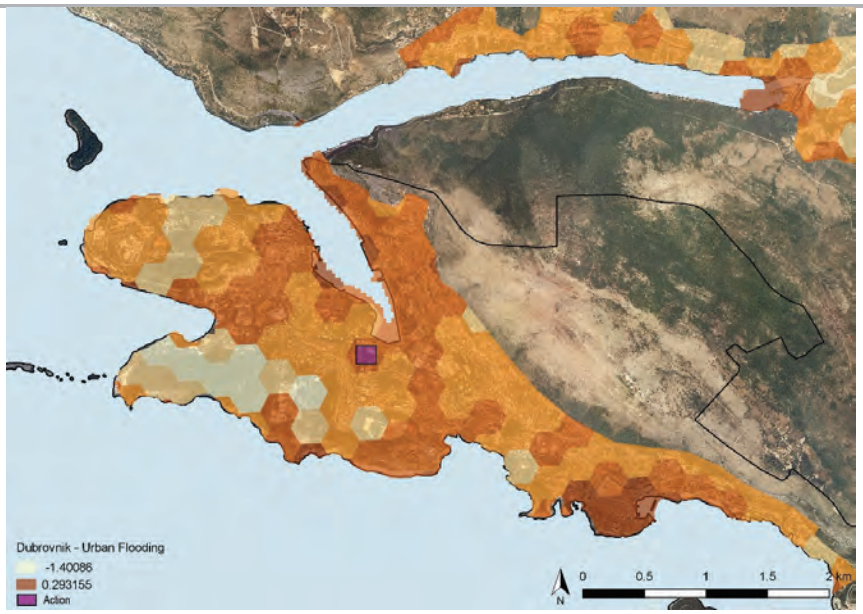
6.1.3 ACTION n° 3:

TITLE *Green roof*	ID HEXAGONS *577*
GENERAL DESCRIPTION	*Urban heat island is caused by absorption of solar energy in buildings and asphalted surfaces and by additional heat produced by industry, traffic, heating and cooling. The green roof is any open space separated from the ground by construction or any other structure and is sown with grass or other plants. They can mainly be divided into extensive and intensive, and layers of which they are made are organic or inorganic. Extensive roofs are characterized by light, low-growth, self-sustainable plants that cover the entire roof area. Extensive green roofs are also called roofs of thorns, eco-roofs or living roofs. Green roofs can mitigate the effect of urban heat island by reducing the surface temperature of the building. The great characteristic of green roofs is that that they not only absorb the heat, but also filter the air in a way where the plants retain polluting air particles and absorb polluted air through the photosynthesis process. Also, water storage can alleviate drainage of water during storms.*
TECHNICAL INFORMATION	*While designing green roofs, it is necessary to:* • *Calculate the bearing capacity of the construction, i.e. the building,* • *Project the slope of the surface for water drainage from the level of waterproofing,* • *Carefully devise drainage paths,* • *Prudently solve the details of the roof edge, attic, various breaches of the flat roof,* • *When planting vegetation with deeper or more aggressive roots, place a barrier for the roots above waterproofing, for example waterproofing with aluminium foil,* • *Customize the security requirements in the area of strong winds or higher buildings* • *Take into account the rules of safety fences on the passage or driving surfaces.* *The project must involve landscape architects.*
KEYWORDS	*#GreenRoof; #ExtremeTemperature; #EnergyDemand*
LOCATION	*Address: Ulica Vladimira Nazora 19, Dubrovnik* *Area: 100 m²* *Geographic coordinates: 42°38'53.25"N, 18° 5'54.63"E (WGS 84/UTM zone 33N)*
MERGE WITH VULNERABILITIES	

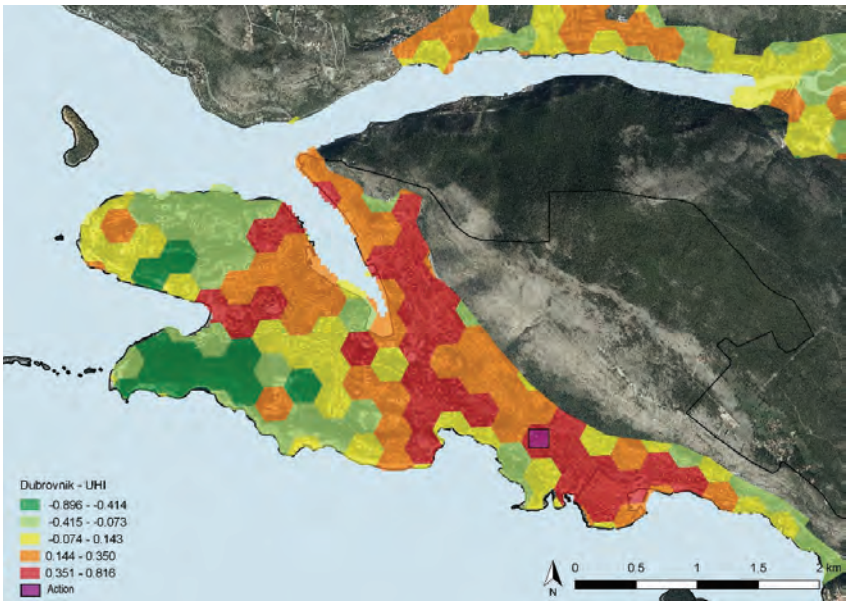
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban heat island; Increased energy demand for cooling*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik*
STAKEHOLDERS INVOLVED	*Vodovod Dubrovnik d.o.o.,* Ministry *of Environment and Energy,* The *Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Employees; Citizens*
TIME OF START/IMPLEMENTATION	*Implementation by 2025*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m^2)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 1,7°C* 2. *Energy use reduction: 7 %* 3. *Flooding area: 1300 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 600*

6.1.4 ACTION n° 4:

TITLE *Green roof*	ID HEXAGONS *420*
GENERAL DESCRIPTION	*Urban heat island is caused by absorption of solar energy in buildings and asphalted surfaces and by additional heat produced by industry, traffic, heating and cooling. The green roof is any open space separated from the ground by construction or any other structure and is sown with grass or other plants. They can mainly be divided into extensive and intensive, and layers of which they are made are organic or inorganic. Extensive roofs are characterized by light, low-growth, self-sustainable plants that cover the entire roof area. Extensive green roofs are also called roofs of thorns, eco-roofs or living roofs. Green roofs can mitigate the effect of urban heat island by reducing the surface temperature of the building. The great characteristic of green roofs is that that they not only absorb the heat, but also filter the air in a way where the plants retain polluting air particles and absorb polluted air through the photosynthesis process. Also, water storage can alleviate drainage of water during storms.*
TECHNICAL INFORMATION	*While designing green roofs, it is necessary to:* • *Calculate the bearing capacity of the construction, i.e. the building,* • *Project the slope of the surface for water drainage from the level of waterproofing,* • *Carefully devise drainage paths,* • *Prudently solve the details of the roof edge, attic, various breaches of the flat roof,* • *When planting vegetation with deeper or more aggressive roots, place a barrier for the roots above waterproofing, for example waterproofing with aluminium foil,* • *Customize the security requirements in the area of strong winds or higher buildings* • *Take into account the rules of safety fences on the passage or driving surfaces.* *The project must involve landscape architects.*
KEYWORDS	*#GreenRoof; #ExtremeTemperature; #EnergyDemand*
LOCATION	*Address: Ulica Marka Marojice 5, Dubrovnik* *Area: 120 m²* *Geographic coordinates: 42°39'2.26"N, 18° 5'1.43"E (WGS 84/UTM zone 33N)*
MERGE WITH VULNERABILITIES	

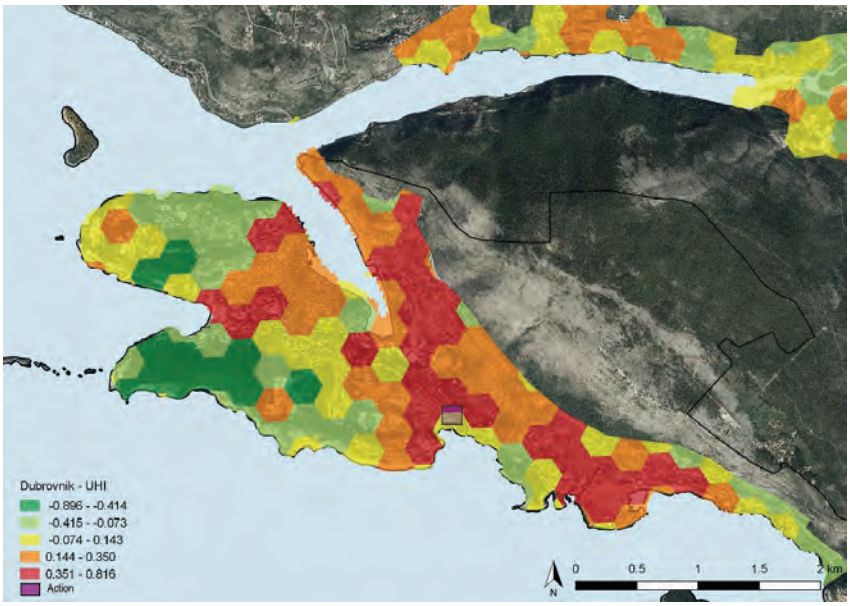
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban heat island; Increased energy demand for cooling*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik*
STAKEHOLDERS INVOLVED	*Sanitat Dubrovnik d.o.o., Ministry of Environment and Energy,* The *Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Employees; Citizens*
TIME OF START/IMPLEMENTATION	*Implementation by 2025.*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m²)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 1,7°C* 2. *Energy use reduction: 7 %* 3. *Flooding area: 800 m²*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 400*

6.1.5 ACTION n° 5:

TITLE	*Natural shading*	ID HEXAGONS	*609*
GENERAL DESCRIPTION	*In summer days extreme temperatures, heat and direct sunlight often reduce the quality of life, and sometimes make it very difficult. A tree is the best and the most beautiful solution for natural shading, which is extremely important during the hot summer months. Apart from the fact that it eases hot days, greenery in the city also contributes to visual characteristics of the city itself.*		
TECHNICAL INFORMATION	*In the vicinity of the existing bus station plant trees or, if that option is not possible, set up jardinieres with trees to provide Sun protection to citizens and visitors of Dubrovnik. In addition to the functional part, bus stations can also serve as information's posts with a purpose of raising public awareness of climate change and the importance of mitigation and adaptation to their consequences. Include landscape architects and traffic experts into the project.*		
KEYWORDS	*#PublicTransport; #NaturalBasedSolution; #HeatWave*		
LOCATION	*Address: /* *Area: 15 m²* *Geographic coordinates: 42°38'45.24"N, 18° 6'7.47"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			
RELATED IMPACT THAT THE ACTION MITIGATES	*Tourism; Extreme temperature; People health*		
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of Traffic*		
STAKEHOLDERS INVOLVED	*Libertas Dubrovnik d.o.o., City of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*		
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*		
TIME OF START/IMPLEMENTATION	*From 2020 to 2023*		
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)*		

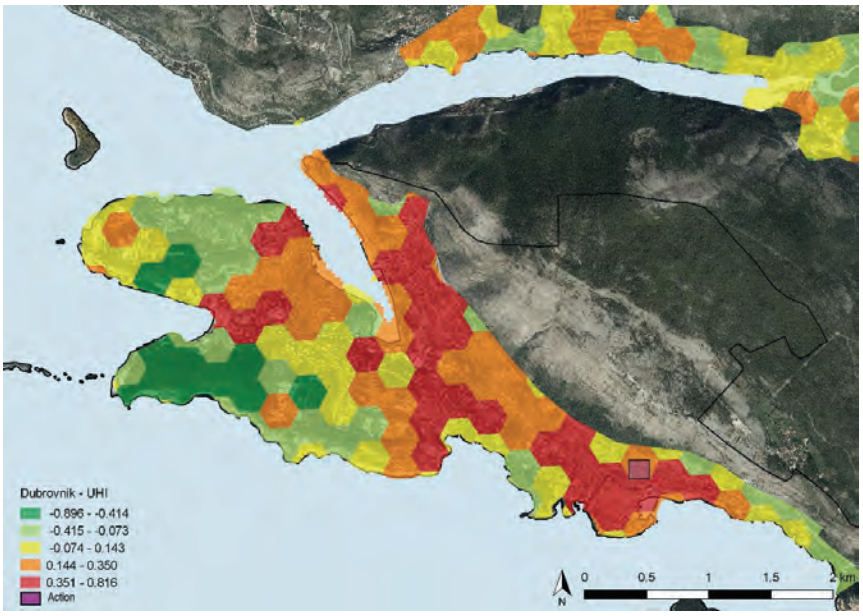
	Flooding area (m^2) *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0,7 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 0 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 1000000*

6.1.6 ACTION n° 6:

TITLE *Natural shading*	ID HEXAGONS *641*
GENERAL DESCRIPTION	*In summer days extreme temperatures, heat and direct sunlight often reduce the quality of life, and sometimes make it very difficult. A tree is the best and the most beautiful solution for natural shading, which is extremely important during the hot summer months. Apart from the fact that it eases hot days, greenery in the city also contributes to visual characteristics of the city itself.*
TECHNICAL INFORMATION	*In the vicinity of the existing bus station plant trees or, if that option is not possible, set up jardinières with trees to provide Sun protection to citizens and visitors of Dubrovnik. In addition to the functional part, bus stations can also serve as information's posts with a purpose of raising public awareness of climate change and the importance of mitigation and adaptation to their consequences. Include landscape architects and traffic experts into the project.*
KEYWORDS	*#PublicTransport; #NaturalBasedSolution; #HeatWave*
LOCATION	*Address: /* *Area: 15 m²* *Geographic coordinates: 42°38'50.64"N, 18° 5'41.01"E (WGS 84/UTM zone 33N)*
MERGE WITH VULNERABILITIES	
RELATED IMPACT THAT THE ACTION MITIGATES	*Tourism; Extreme temperature; People health*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*
STAKEHOLDERS INVOLVED	*Libertas Dubrovnik d.o.o., City of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2023*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)*

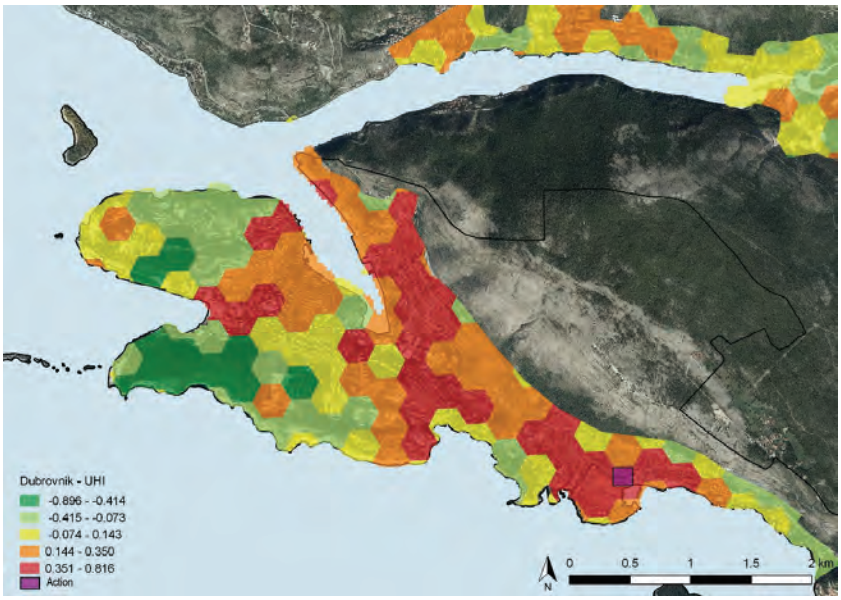
	Flooding area (m^2) *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0,7 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 0 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 1000000*

6.1.7 ACTION n° 7:

TITLE	*Natural shading*	ID HEXAGONS	*703*
GENERAL DESCRIPTION	*In summer days extreme temperatures, heat and direct sunlight often reduce the quality of life, and sometimes make it very difficult. A tree is the best and the most beautiful solution for natural shading, which is extremely important during the hot summer months. Apart from the fact that it eases hot days, greenery in the city also contributes to visual characteristics of the city itself.*		
TECHNICAL INFORMATION	*In the vicinity of the existing bus station plant trees or, if that option is not possible, set up jardinières with trees to provide Sun protection to citizens and visitors of Dubrovnik. In addition to the functional part, bus stations can also serve as information's posts with a purpose of raising public awareness of climate change and the importance of mitigation and adaptation to their consequences. Include landscape architects and traffic experts into the project.*		
KEYWORDS	*#PublicTransport; #NaturalBasedSolution; #HeatWave*		
LOCATION	*Address: /* *Area: 15 m²* *Geographic coordinates: 42°38'35.68"N, 18° 6'42.44"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			
RELATED IMPACT THAT THE ACTION MITIGATES	*Tourism; Extreme temperature; People health*		
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*		
STAKEHOLDERS INVOLVED	*Libertas Dubrovnik d.o.o., City of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*		
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*		
TIME OF START/IMPLEMENTATION	*From 2020 to 2023*		
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)*		

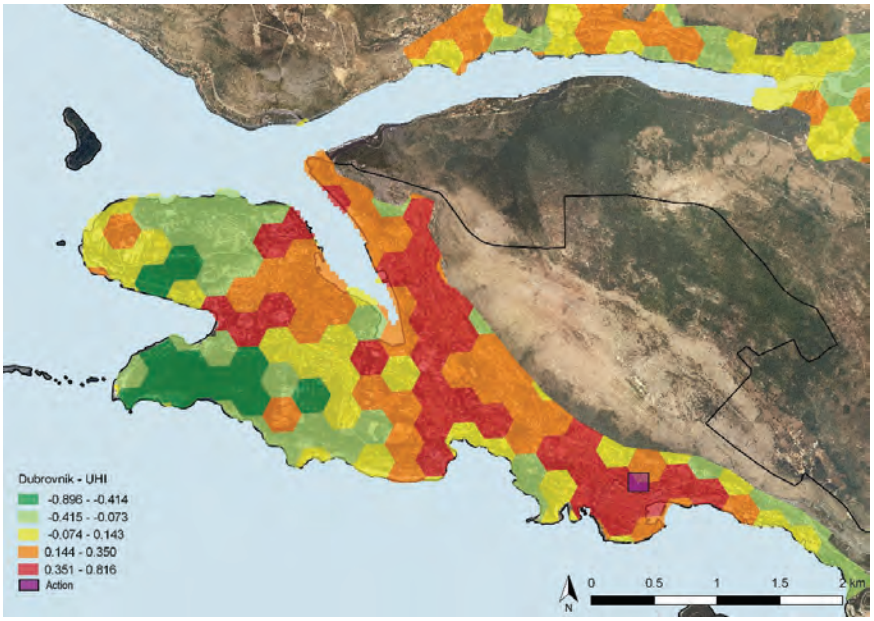
	Flooding area (m^2) *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0,7 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 0 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 1000000*

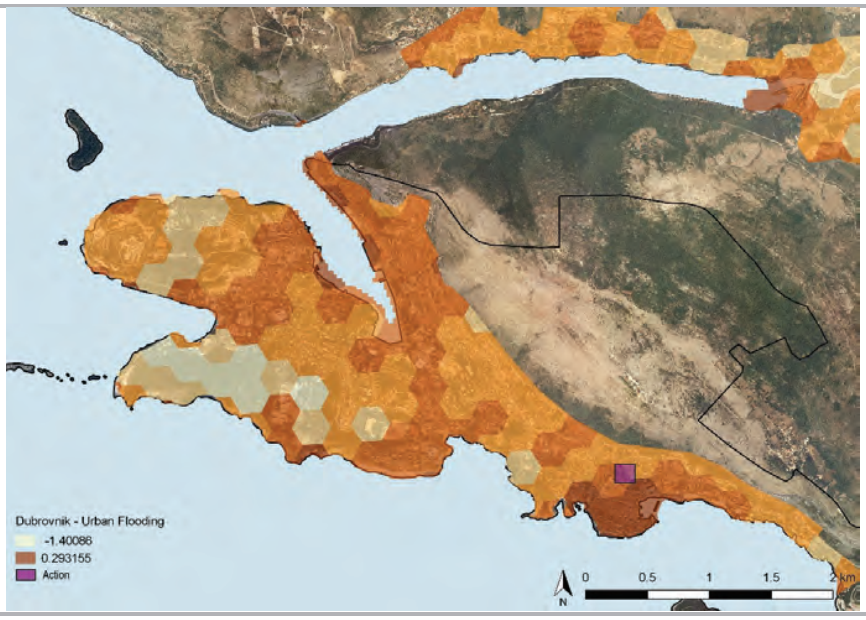
6.1.8 ACTION n° 8:

TITLE	*Natural shading*	ID HEXAGONS	*704*
GENERAL DESCRIPTION	*In summer days extreme temperatures, heat and direct sunlight often reduce the quality of life, and sometimes make it very difficult. A tree is the best and the most beautiful solution for natural shading, which is extremely important during the hot summer months. Apart from the fact that it eases hot days, greenery in the city also contributes to visual characteristics of the city itself.*		
TECHNICAL INFORMATION	*In the vicinity of the existing bus station plant trees or, if that option is not possible, set up jardinières with trees to provide Sun protection to citizens and visitors of Dubrovnik. In addition to the functional part, bus stations can also serve as information's posts with a purpose of raising public awareness of climate change and the importance of mitigation and adaptation to their consequences. Include landscape architects and traffic experts into the project.*		
KEYWORDS	*#PublicTransport; #NaturalBasedSolution; #HeatWave*		
LOCATION	*Address: /* *Area: 15 m²* *Geographic coordinates: 42°38'32.57"N, 18° 6'41.72"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			
RELATED IMPACT THAT THE ACTION MITIGATES	*Tourism; Extreme temperature; People health*		
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*		
STAKEHOLDERS INVOLVED	*Libertas Dubrovnik d.o.o., City of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*		
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*		
TIME OF START/IMPLEMENTATION	*From 2020 to 2023*		
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)*		

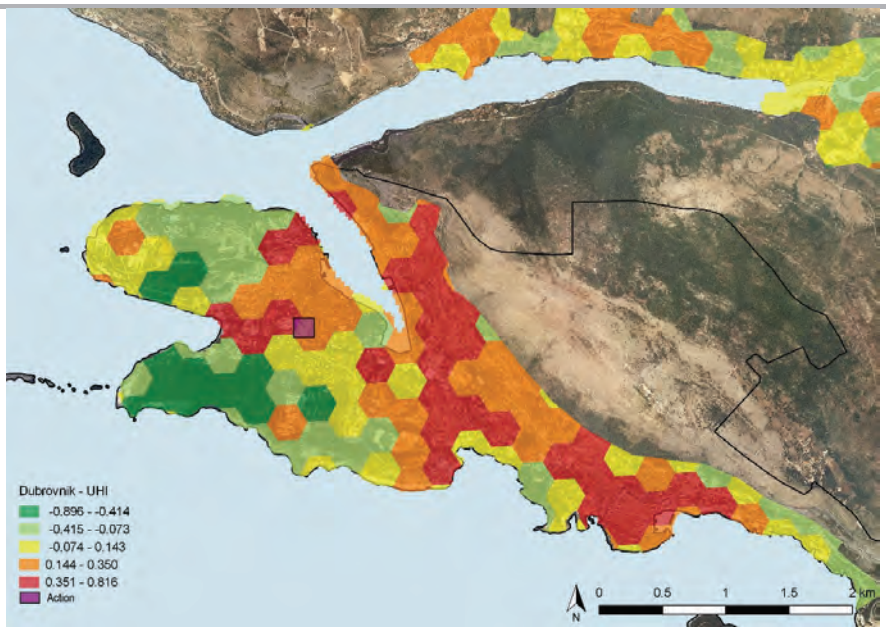
	Flooding area (m^2) *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0,7 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 0 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: medium*
C-SOCIAL	6. *People who will benefit from the actions: 1000000*

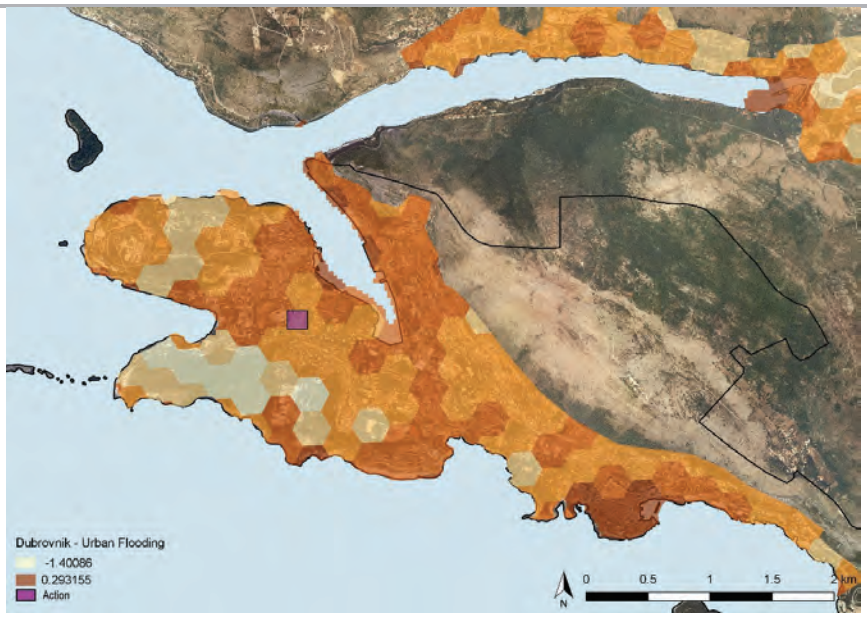
6.1.9 ACTION n° 9:

TITLE	*Green parking lot*	ID HEXAGONS	*672, 704*
GENERAL DESCRIPTION	*Green parking lots are made of permeable surface that is designed to allow precipitation to infiltrate through their openings in the underground. This increases the water infiltration into the soil, and thus the replenishment of groundwater reserves and soil moisture. It also reduces the amount and the rate of run-off on the ground, which helps reduce the risk of flooding. Green parking spaces provide rainwater management on site, allowing ground penetration during storms. They can completely eliminate run-off in small storm events and have the ability to capture as much as 50-80 % of the fun-off from the bigger storm events. The choice of cold paving material that is lightly painted and prone to allowing air movement and evaporation can help combat urban heat island phenomenon.*		
TECHNICAL INFORMATION	*Green parking lots include prefabricated panels with openings through which water can infiltrate the ground. Parking spaces should be painted in bright colours that reflect sunlight and so reduce air temperature. Landscape architects should be included in the project.*		
KEYWORDS	*#ParkingLot; #UrbanHeatIsland; #UrbanFlooding*		
LOCATION	*Adress: /* *Area: 1620 m²* *Geographic coordinates: 42°38'32.62"N, 18° 6'36.64"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			

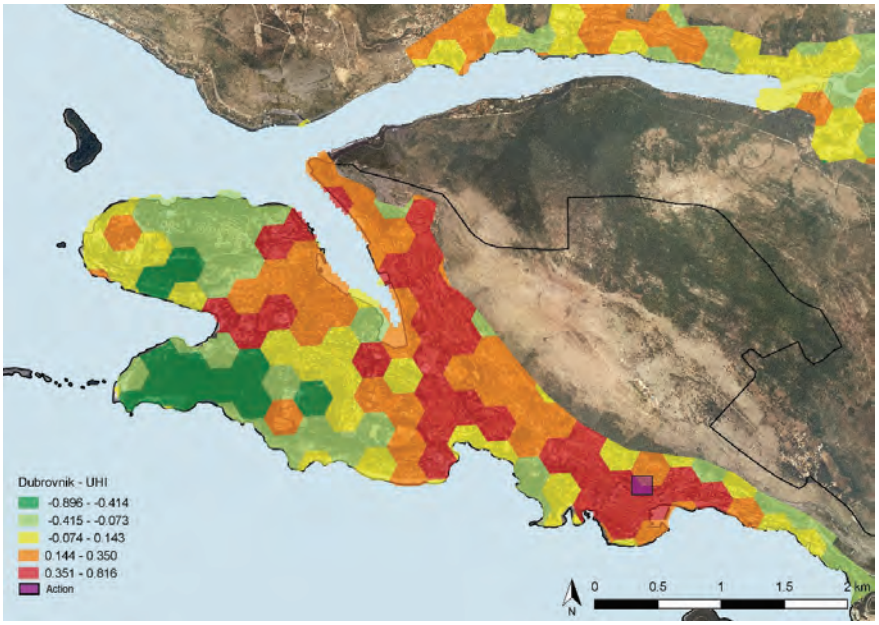
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban Flooding; Extreme Temperatures; Tourism*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*
STAKEHOLDERS INVOLVED	*SANITAT DUBROVNIK d.o.o., City of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2025*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m^2)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 2,3 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 13160 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: high*
C-SOCIAL	6. *People who will benefit from the actions: 15000*

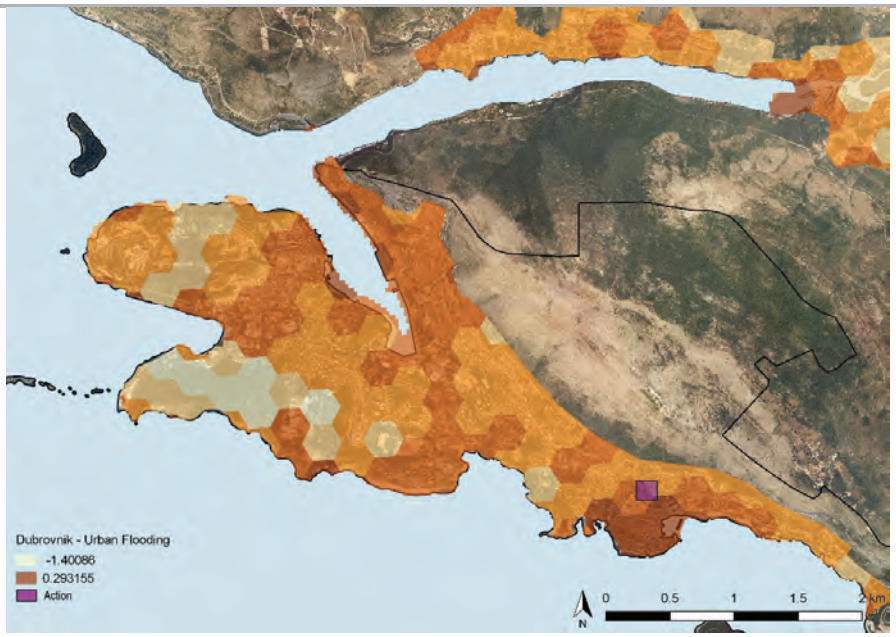
6.1.10 ACTION n°10:

TITLE	*Green parking spaces with filter strip*	ID HEXAGONS	*357*
GENERAL DESCRIPTION	*Water traps are permeable strips covered with vegetation, located in urban areas between impermeable (asphalted and / or concrete) urban surfaces. Inside the strips can also be grown decorative plants and tall trees, which significantly affect the aesthetical and ecological improvement of the urban scenery as well as mitigation of urban heat phenomenon. Such green strips affect infiltration increase, flood size reduction and pollutant and sediment filtration, thus protesting the environment in the cities and settlements. The represent a green alternative to conventional systems of surface sewer. By providing shade, increasing evapotranspiration and converting sunlight to plant material via photosynthesis instead absorbing it, plant and trees have a cooling effect on the environment. Brightly coloured parking spaces increase surface albedo and help alleviate urban heat islands.*		
TECHNICAL INFORMATION	*At the centre of parking space make a filter strip where trees will be planted. Parking spaces paint in bright colours that reflect sunlight and thus reduce air temperature. Landscape architects should be included in the project.*		
KEYWORDS	*#GreenParkingLot; #UrbanFlooding; #UrbanHeatIsland*		
LOCATION	*Adress: /* *Area: 2000 m²* *Geographic coordinates: 42°39'18.44"N, 18°4'41.37"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			

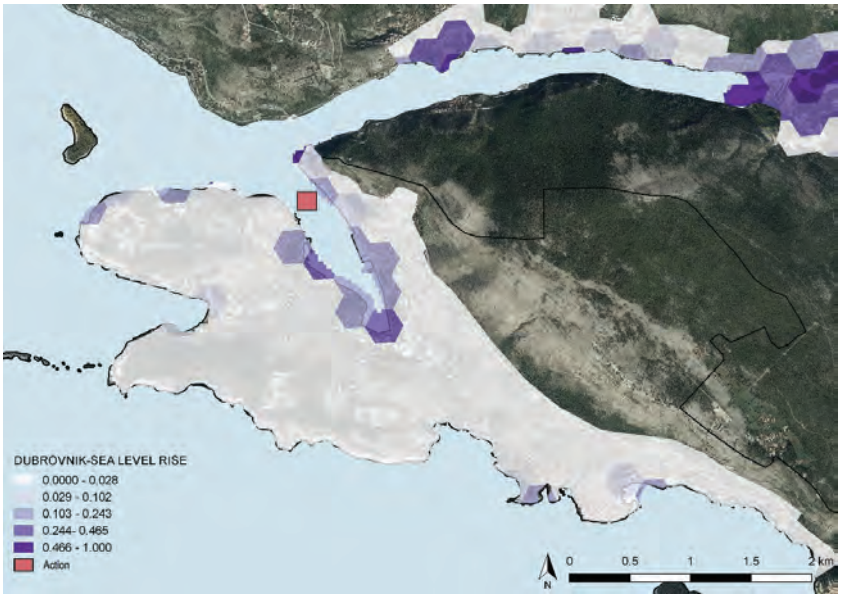
	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban Flooding; Extreme Temperatures; Tourism*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*
STAKEHOLDERS INVOLVED	*SANITAT DUBROVNIK d.o.o.,* City *of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2025*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m²)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 2,3 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 5000 m²*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: high*
C-SOCIAL	6. *People who will benefit from the actions: 73000*

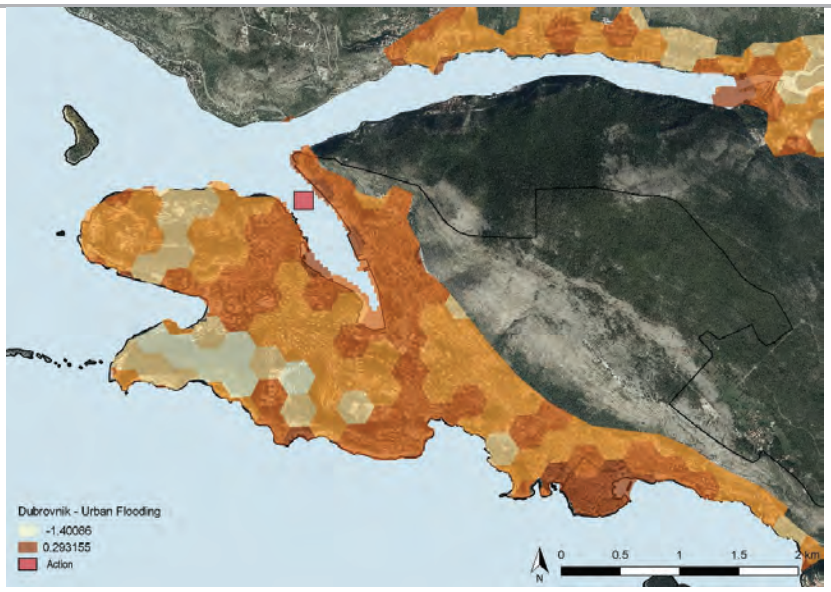
6.1.11 ACTION n°11:

TITLE	*Green parking lot*	ID HEXAGONS	*704*
GENERAL DESCRIPTION	*Green parking lots are made of permeable surface that is designed to allow precipitation to infiltrate through their openings in the underground. This increases the water infiltration into the soil, and thus the replenishment of groundwater reserves and soil moisture. It also reduces the amount and the rate of run-off on the ground, which helps reduce the risk of flooding. Trees provide shade, increasing evapotranspiration and transforming sunlight into plant material by photosynthesis process instead of absorbing it and therefore have a cooling effect on the environment. Brightly coloured parking spaces increase albedo surface and thus alleviate urban heat islands.*		
TECHNICAL INFORMATION	*Parking area will be renewed so that the substrate is made of permeable surfaces with establishment of green belts in the middle and on the edges of parking area where native trees will be planted. Parking area should be coloured in bright colours that reflect sunlight and thus reduce the air temperature. Landscape architects should be included in the project.*		
KEYWORDS	*#GreenParkingLot; #UrbanFlooding; #UrbanHeatIsland*		
LOCATION	*Adress: /* *Area: 2000 m²* *Geographic coordinates: 42°38'33.71"N, 18° 6'39.42"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			

	
RELATED IMPACT THAT THE ACTION MITIGATES	*Urban Flooding; Extreme Temperatures; Tourism*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik – Administrative Department of traffic*
STAKEHOLDERS INVOLVED	*SANITAT DUBROVNIK d.o.o.,* City *of Dubrovnik, The Environmental Protection and Energy Efficiency Fund, City of Dubrovnik Development Agency (DURA)*
BENEFICIARIES/TARGET GROUP	*Citizens; Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2025*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m²)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 2,3 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 7000 m²*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: high* 5. *Political acceptability: high*
C-SOCIAL	6. *People who will benefit from the actions: 39500*

6.1.12 ACTION n°12:

TITLE	*The mobile barriers*	ID HEXAGONS	*354, 385*
GENERAL DESCRIPTION	*Modelled after the project Mose in Venice, build a mobile barrier at the selected location that will prevent flooding caused by rising sea level. The idea is that before the flood arrival, specially designed underwater barrage close entrance to Port Gruž.*		
TECHNICAL INFORMATION	*Under normal tidal conditions, the gates are full of water and rest in their housing structures. When a high tide is forecast, compressed air is introduced into the gates to empty them of water, causing them to rotate around the axis of the hinges and rise up until they emerge above the water to stop the tide from entering Port Gruž. When the tide drops, the gates are filled with water again and return to their housing.*		
KEYWORDS	*#SeaLevelRise; #MobileBarriers; #UrbanFlooding*		
LOCATION	*Adress: /* *Area:9000 m²* *Geographic coordinates: 42°39'50.19"N, 18° 4'44.20"E (WGS 84/UTM zone 33N)*		
MERGE WITH VULNERABILITIES			

	
RELATED IMPACT THAT THE ACTION MITIGATES	*Sea level rise; Urban flooding;*
PROJECT INITIATOR/PROMOTER	*City of Dubrovnik*
STAKEHOLDERS INVOLVED	*City of Dubrovnik*, Ministry *of Environment and Energy, City of Dubrovnik Development Agency (DURA), Dubrovnik Port Authority*
BENEFICIARIES/TARGET GROUP	*Citizens, Visitors*
TIME OF START/IMPLEMENTATION	*From 2020 to 2040*
INDICATORS OF EVALUATION:	*Uhi reduction (°C)* *Energy use reduction (%)* *Flooding area (m^2)* *People acceptability (low-medium-high)* *Political acceptability (low-medium-high)* *People who will benefit from the actions (n. of people)*
A-ENVIRONMENTAL	1. *Uhi reduction: 0 °C* 2. *Energy use reduction: 0 %* 3. *Flooding area: 2250000 m^2*
B-LEGAL, INSTITUTIONAL & PERCEPTIONAL	4. *People acceptability: low* 5. *Political acceptability: low*
C-SOCIAL	6. *People who will benefit from the actions: 35000*

6.2 DSS: action evaluation

iDeal project aims to support local public administrations to make appropriate decisions related to climate adaptation measures and to develop coherent and tailored climate adaptation plans for both Croatian and Italian territories.

This overall objective will be achieved through a shared process of knowledge construction and the implementation of a common Decision Support System. DSS is a system that can support decision-making activities. It is an interactive system able to analyse through different criteria a set of information and support an administration in the governance process, based on the datasheets and parameters.

The prevention, or at least reduction, of most diffuse effects of climate change affecting Italy-Croatia regions (overall extreme weather events, intensification of fires, drought, flooding, landslides) should be supported by the public sector which is better organized in the field of data and information available.

Each Partner has its own DSS. The main objectives are reported, in connection with the indicators chosen by the PP.

When evaluating, it is necessary to determine the "Weight" of each result. Weights measure the preference intensity, i.e. how important objectives and indicators are in relation to other objectives and indicators, in order to achieve the main goal. The evaluation is performed as an assessment of alternatives using the weighted objectives and indicators.

In addition, it is necessary to define the value of the upper and lower thresholds for each indicator. Thresholds must be able to discriminate for each indicator an *acceptable*, a *good* and an *unacceptable* result. Thresholds must be identified considering the current context and future expectations and must be realistic, feasible and goal oriented.

Values assigned to each action, as well as DSS results for each action are presented below.

6.2.1 ACTION EVALUATION n°1 - Parking lots alteration

The table below (Table 6.1) shows the values assigned to objectives and indicators of the Action 1.

Table 6.1 DSS values assigned for Acton 1

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	7000	12000	0,4	12300	good
		Uhi reduction	0,5	4	0,4	2,5	acceptable
		Energy use reduction	0	10	0,2	0	good
B. Social Aspect	0,2	People who will benefit from the actions n. Of people)	5000	30000	1	16000	acceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,4	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnera ble	good

The graphs below (Figure 6.1, Figure 6.2) show the results for objectives and criteria of the Action 1. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

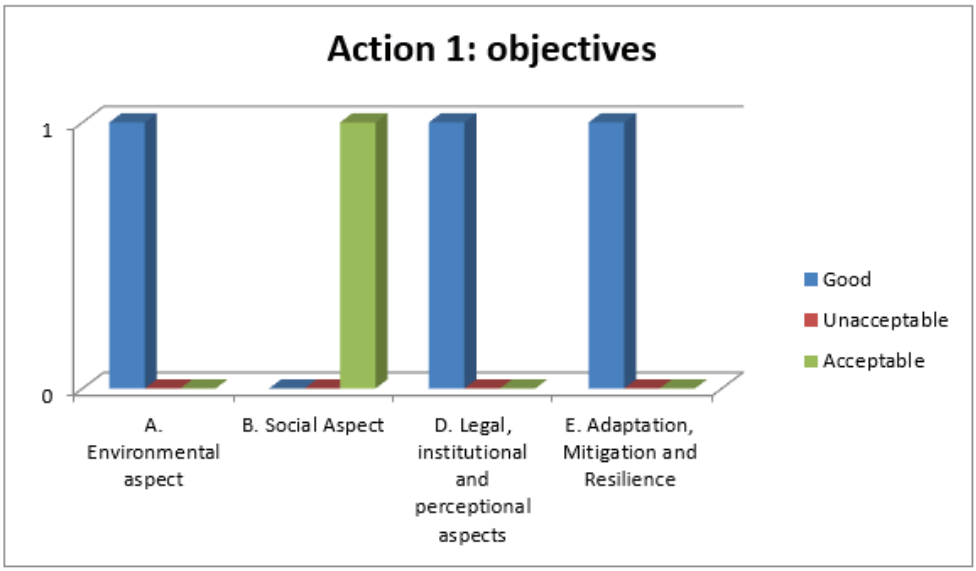


Figure 6.1 DSS results for objectives of Action 1

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.2).

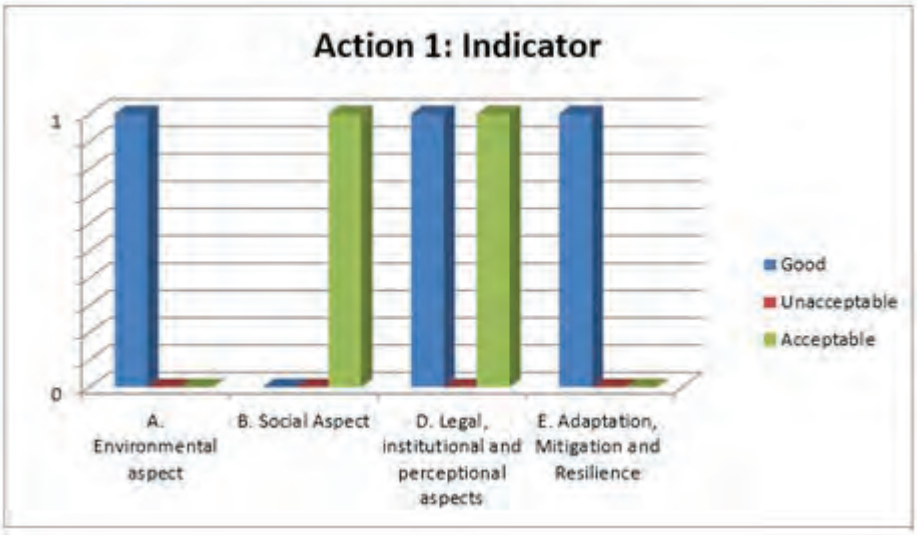


Figure 6.2 DSS results for indicators of Action 1

Based on the analysis of objectives and indicators, Action n°1 was evaluated as *good*.

6.2.2 ACTION EVALUATION n°2 - Sea Wall

The table below (Table 6.2) shows the values assigned to the objectives and indicators of Action 2.

Table 6.2 DSS values assigned for Acton 2

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Unacceptable
A. Environmental aspect	0,3	Flooding area	3000000	5000000	0,8	2250000	unacceptable
		Uhi reduction	0	4	0,1	0	good
		Energy use reduction	3	10	0,1	0	good
B. Social Aspect	0,4	People who will benefit from the actions n. of people)	20000	50000	1	12000	unacceptable
D. Legal, institutional and perceptional aspects	0,1	People acceptability	1	3	0,5	1	acceptable
		Political acceptability	1	3	0,5	1	acceptable
E. Adaptation, Mitigation and Resilience	0,2	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.3, Figure 6.4) show the results for the objectives and criteria of Action 2. The objectives in the Environmental and Social aspect group were rated as *unacceptable*, the Legal, institutional and perceptional aspect group is *acceptable*, while the Adaptation, Mitigation and Resilience group were evaluated as *good*.

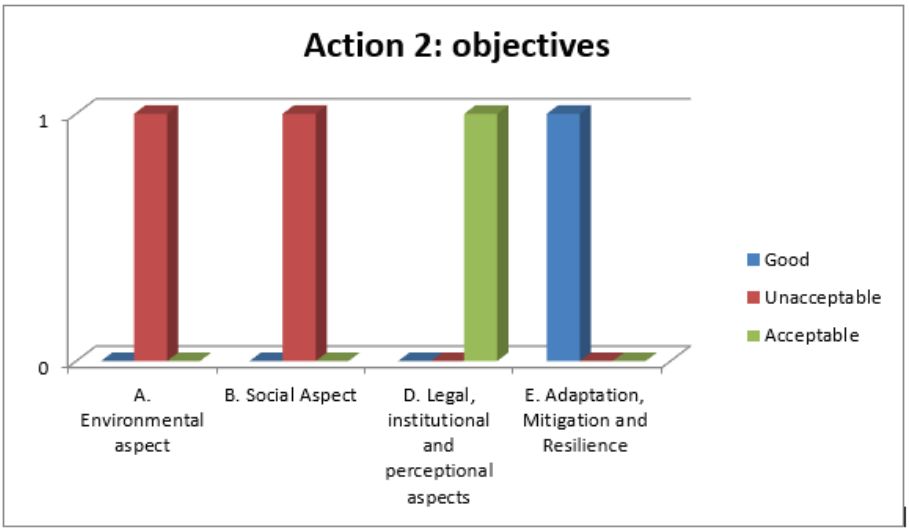


Figure 6.3 DSS results for objectives of Action 2

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.4).

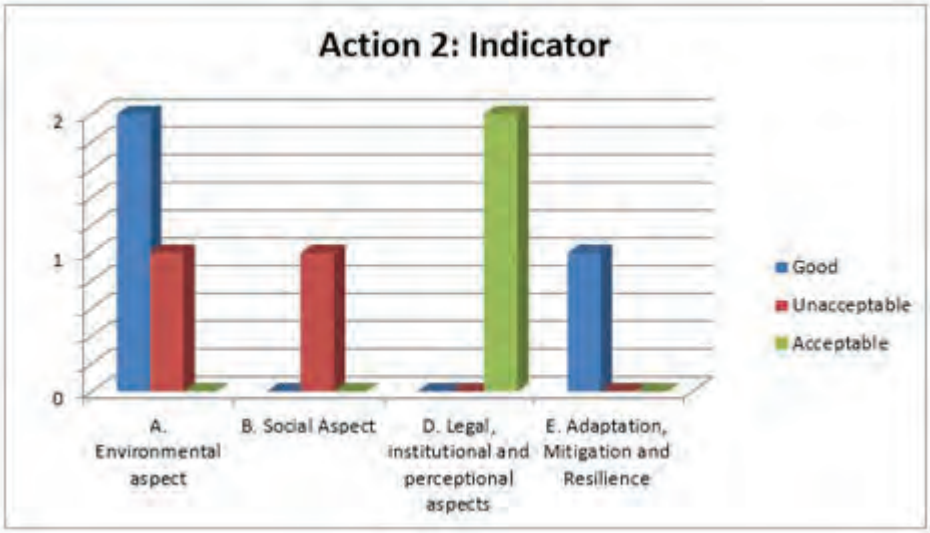


Figure 6.4 DSS results for indicators of Action 2

Based on the analysis of objectives and indicators, Action n°2 was evaluated as *unacceptable*.

6.2.3 ACTION EVALUATION n°3 - Green roof

The table below (Table 6.3Table 6.2) shows the values assigned to the objectives and indicators of Action 3.

Table 6.3 DSS values assigned for Acton 3

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,3	Flooding area	1000	4000	0,2	1300	acceptable
		Uhi reduction	2	4	0,3	1,7	good
		Energy use reduction	8	10	0,5	7	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	100	1000	1	600	acceptable
D. Legal, institutional and perceptional aspects	0,1	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.5, Figure 6.6) show the results for the objectives and criteria of Action 3. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

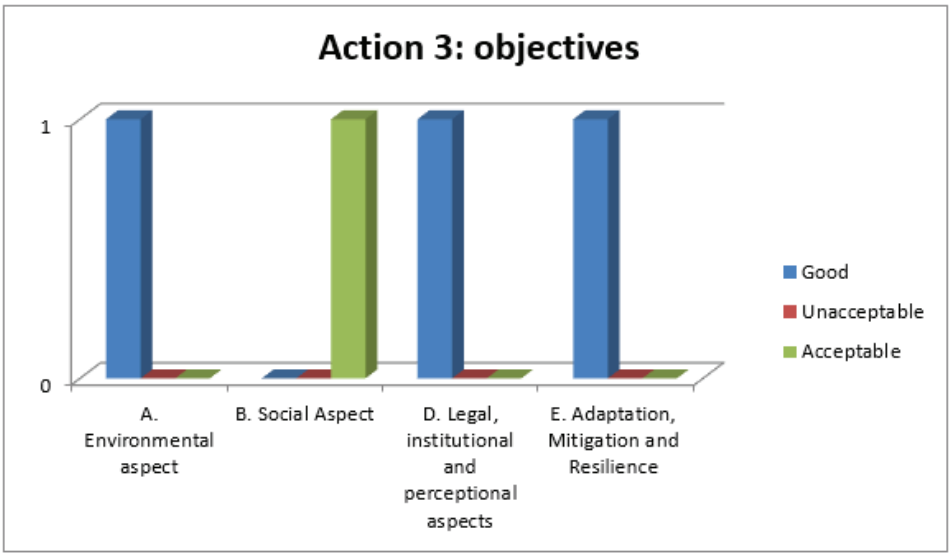


Figure 6.5 DSS results for objectives of Action 3

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.6).

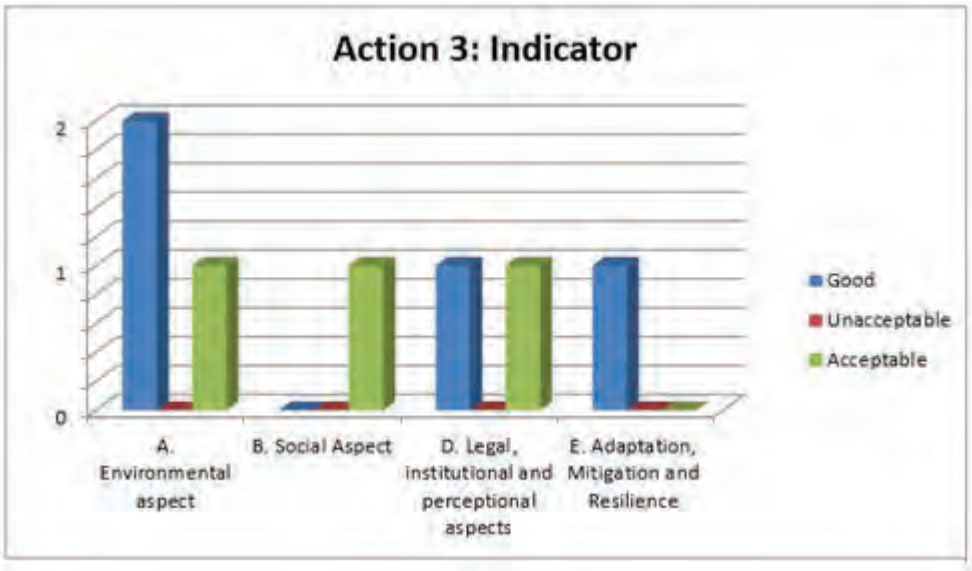


Figure 6.6 DSS results for indicators of Action 3

Based on the analysis of objectives and indicators, Action n°3 was evaluated as *good.*

6.2.4 ACTION EVALUATION n°4 - Green roof

The table below (Table 6.4) shows the values assigned to the objectives and indicators of Action 4.

Table 6.4 DSS values assigned for Acton 4

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,3	Flooding area	500	2000	0,2	800	acceptable
		Uhi reduction	2	4	0,3	1,7	good
		Energy use reduction	8	10	0,5	7	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	100	1000	1	400	acceptable
D. Legal, institutional and perceptional aspects	0,1	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.7, Figure 6.8) show the results for the objectives and criteria of Action 4. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

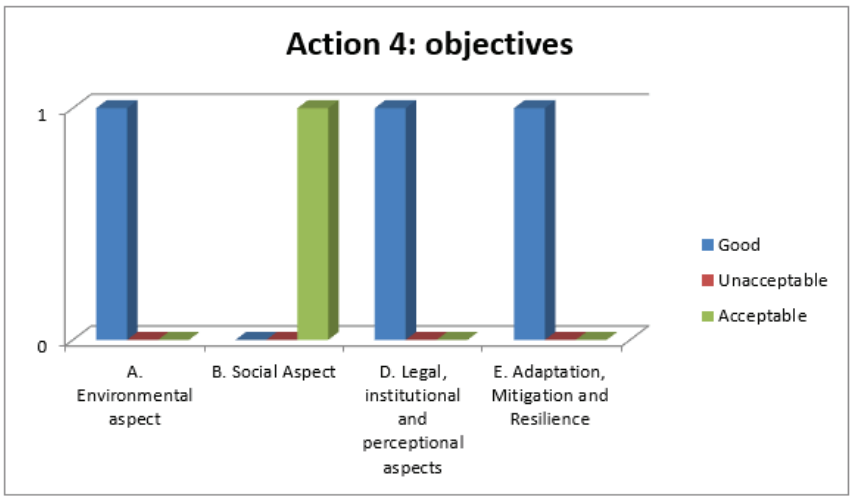


Figure 6.7 DSS results for objectives of Action 4

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.8Figure 6.6).

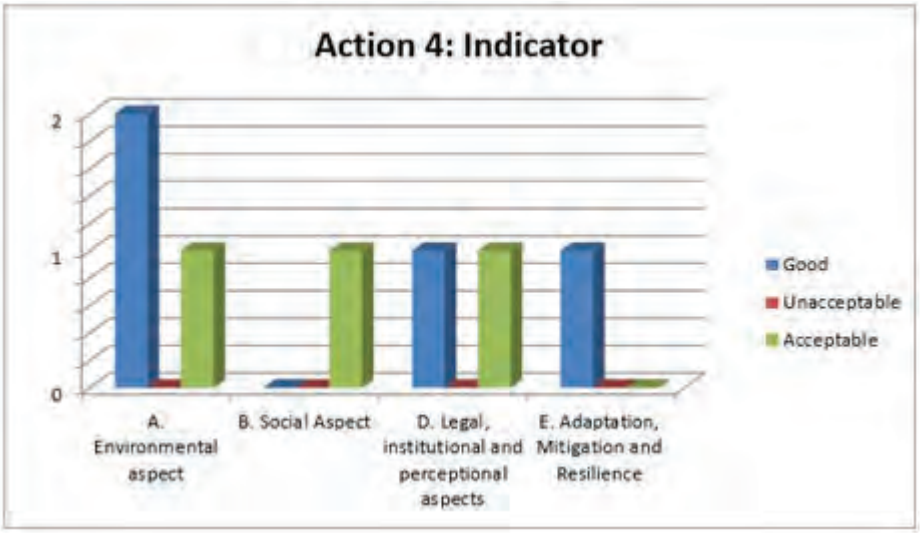


Figure 6.8 DSS results for indicators of Action 4

Based on the analysis of objectives and indicators, Action n°4 was evaluated as *good*.

6.2.5 ACTION EVALUATION n°5 - Natural shading

The table below (Table 6.5) shows the values assigned to the objectives and indicators of Action 5.

Table 6.5 DSS values assigned for Acton 5

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	0	10	0,1	0	acceptable
		Uhi reduction	0,5	3	0,8	0,7	acceptable
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	5000000	15000000	1	1000000	unacceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.9, Figure 6.10) show the results for the objectives and criteria of Action 5. The objectives in the Environmental aspect group were rated as *acceptable*, the Social aspect group is *unacceptable*, while the Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good*.

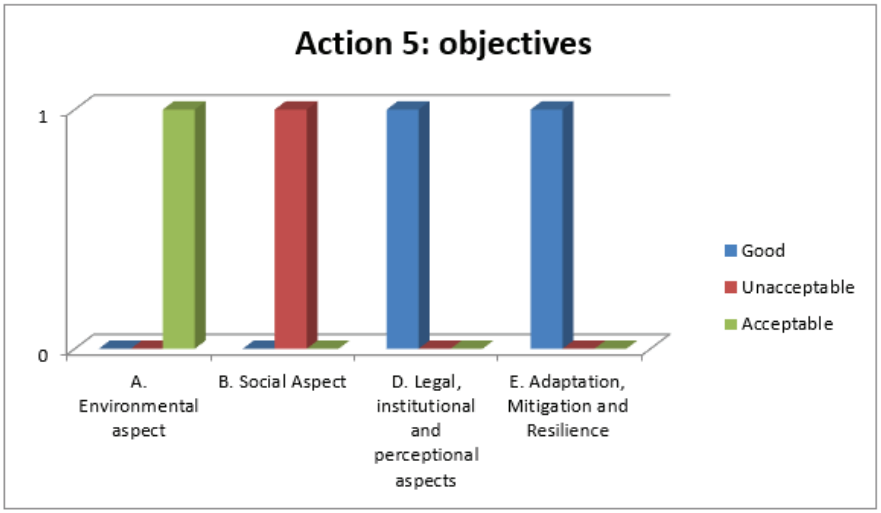


Figure 6.9 DSS results for objectives of Action 5

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.10).

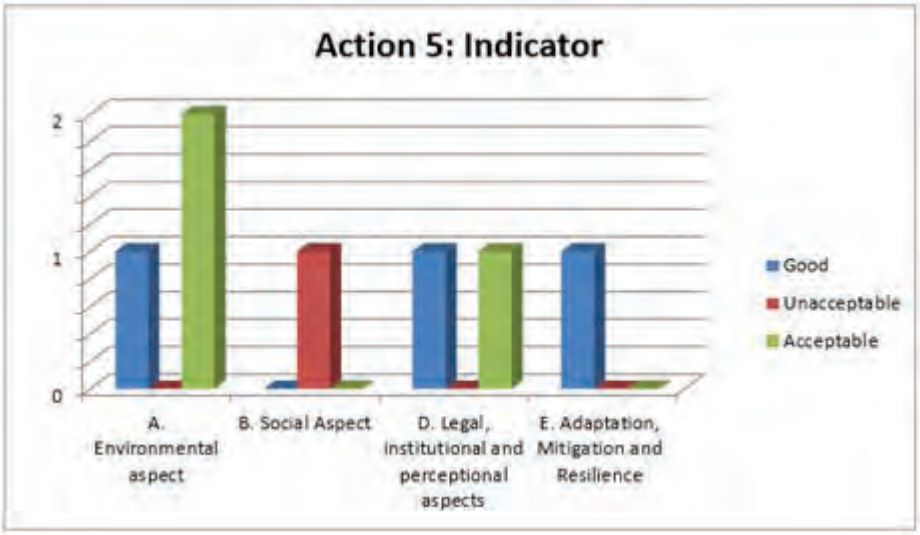


Figure 6.10 DSS results for indicators of Action 5

Based on the analysis of objectives and indicators, Action n°5 was evaluated as *good*.

6.2.6 ACTION EVALUATION n°6 - Natural shading

The table below (Table 6.5) shows the values assigned to the objectives and indicator of Action 6.

Table 6.6 DSS values assigned for Acton 6

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	0	10	0,1	0	acceptable
		Uhi reduction	0,5	3	0,8	0,7	acceptable
		Energy use reduction	2	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	6000000	15000000	1	1000000	unacceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.11, Figure 6.12) show the results for the objectives and criteria of Action 6. The objectives in the Environmental aspect group were rated as *acceptable*, the Social aspect group is *unacceptable*, while the Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good*.

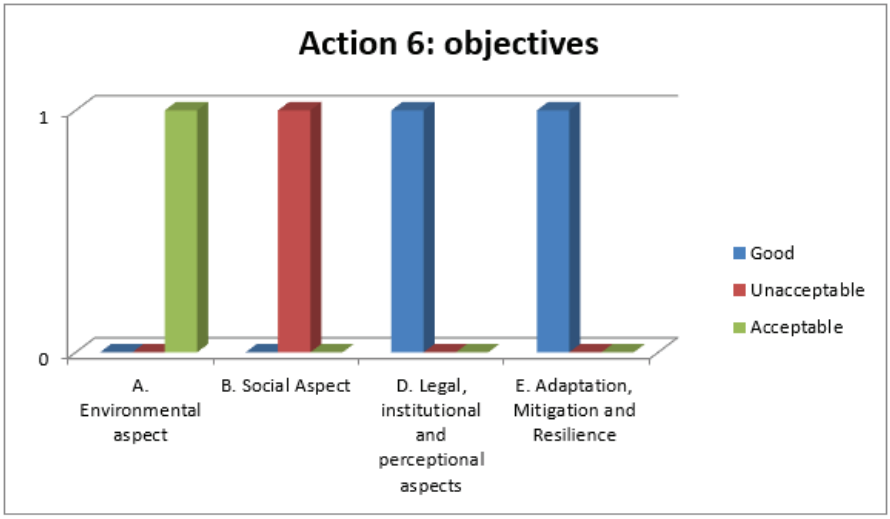


Figure 6.11 DSS results for objectives of Action 6

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.12).

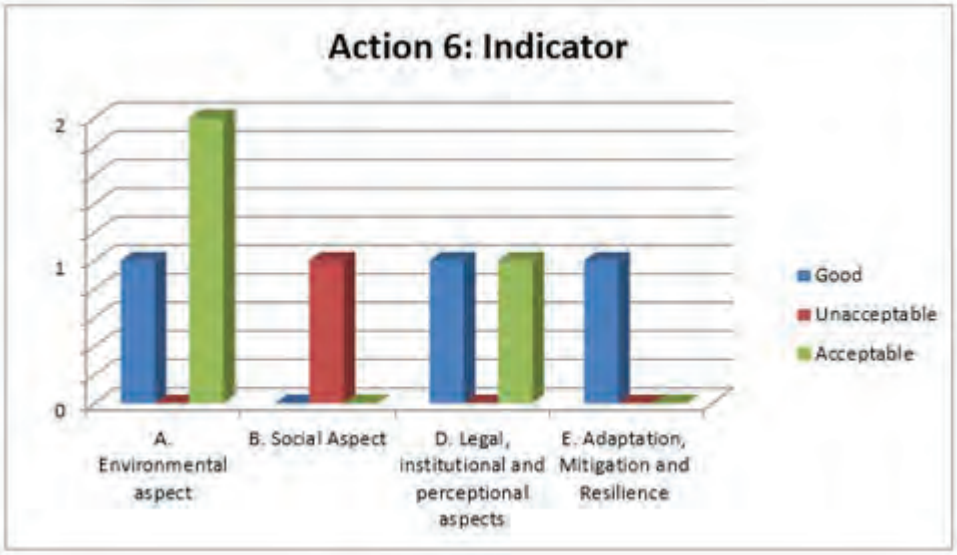


Figure 6.12 DSS results for indicators of Action 6

Based on the analysis of objectives and indicators, Action n°6 was evaluated as *good*.

6.2.7 ACTION EVALUATION n°7 - Natural shading

The table below (Table 6.7) shows the values assigned to the objectives and indicators of Action 7.

Table 6.7 DSS values assigned for Acton 7

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	0	10	0,1	0	acceptable
		Uhi reduction	0,5	3	0,8	0,7	acceptable
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	5000000	15000000	1	1000000	unacceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.13, Figure 6.14) show the results for the objectives and criteria of Action 7. The objectives in the Environmental aspect group were rated as *acceptable*, the Social aspect group is *unacceptable*, while the Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good*.

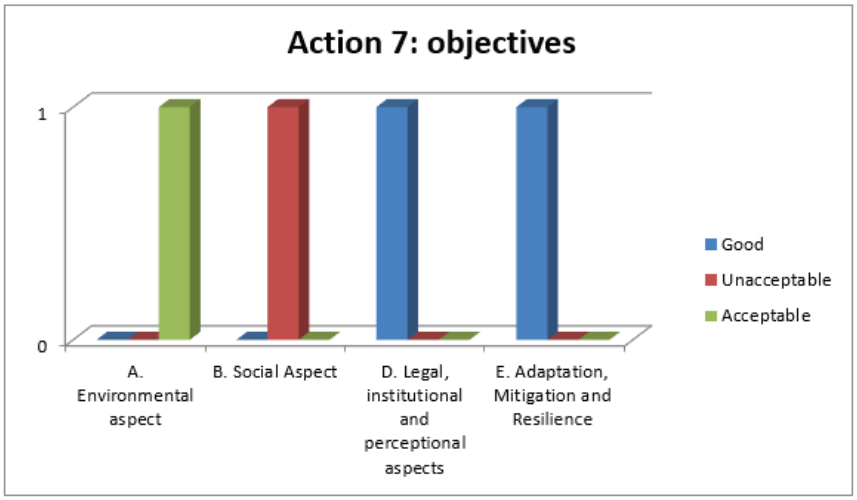


Figure 6.13 DSS results for objectives of Action 7

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.12).

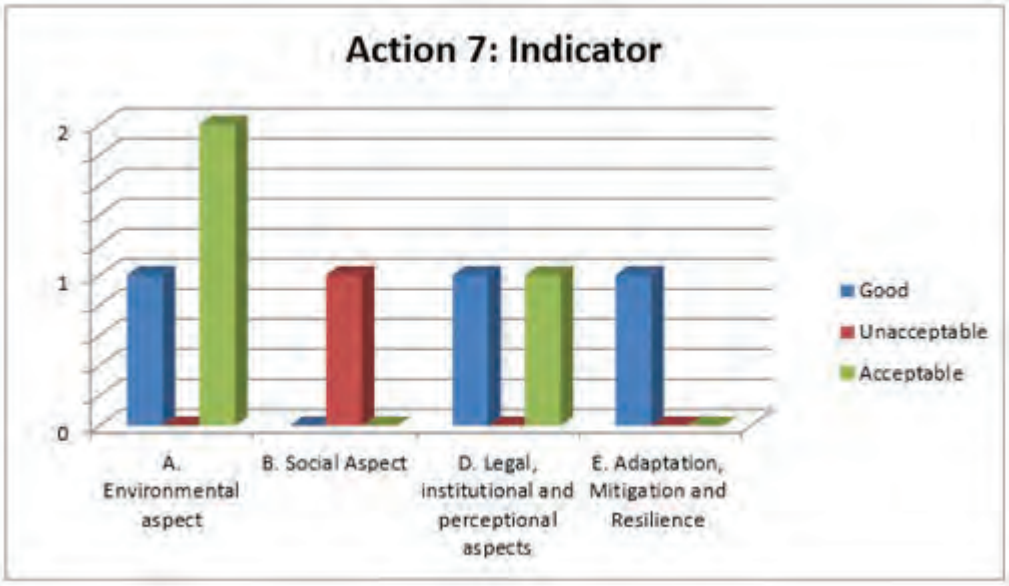


Figure 6.14 DSS results for indicator of Action 7

Based on the analysis of objectives and indicators, Action n°7 was evaluated as *good*.

6.2.8 ACTION EVALUATION n°8 - Natural shading

The table below (Table 6.8) shows the values assigned to the objectives and indicators of Action 8.

Table 6.8 DSS values assigned for Acton 8

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	0	10	0,1	0	acceptable
		Uhi reduction	0,5	3	0,8	0,7	acceptable
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	5000000	15000000	1	1000000	unacceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	2	acceptable
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.15, Figure 6.16) show the results for the objectives and criteria of Action 8. The objectives in the Environmental aspect group were rated as *acceptable*, the Social aspect group is *unacceptable*, while the Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good*.

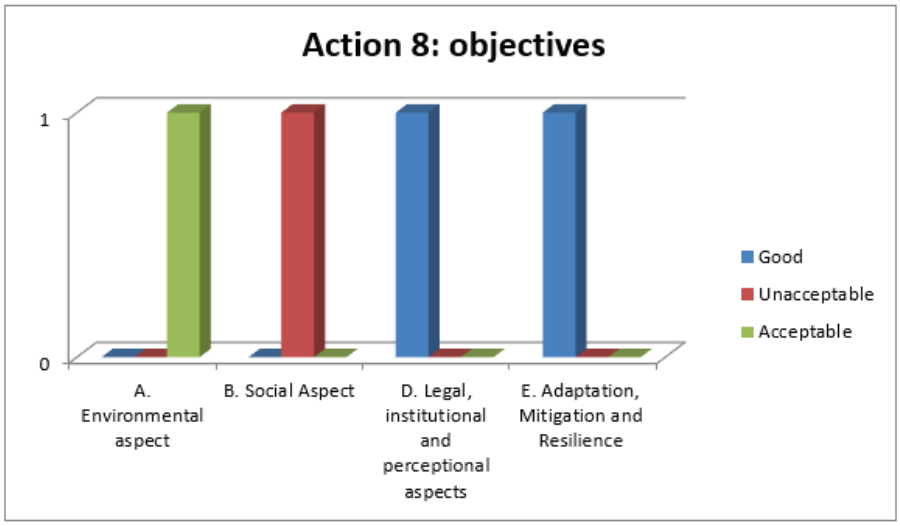


Figure 6.15 DSS results for objectives of Action 8

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.16).

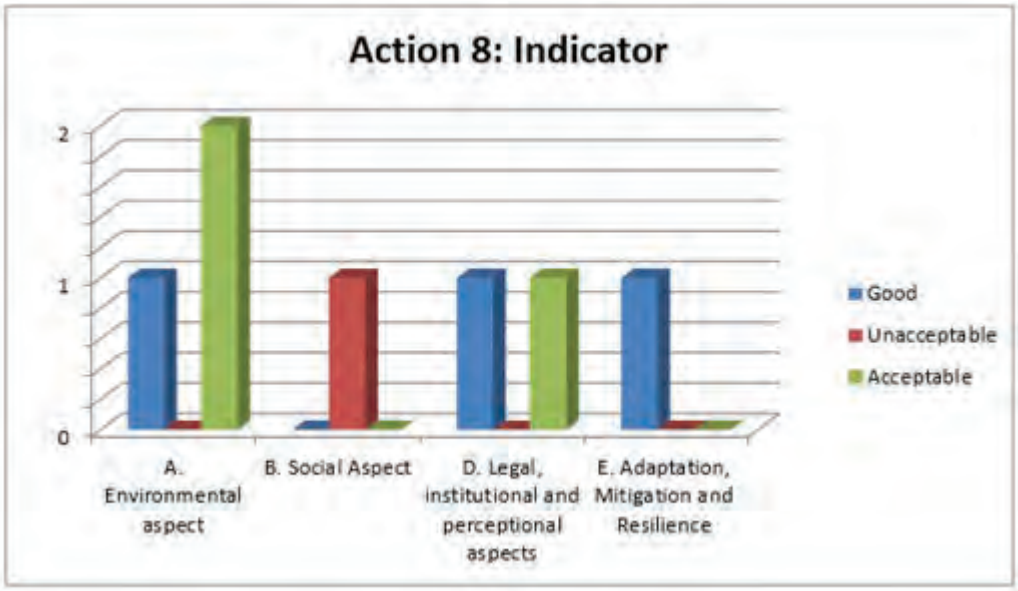


Figure 6.16 DSS results for indicators of Action 8

Based on the analysis of objectives and indicators, Action n°8 was evaluated as *good*.

6.2.9 ACTION EVALUATION n°9 - Green parking lot

The table below (Table 6.9) shows the values assigned to the objectives and criteria of Action 9.

Table 6.9 DSS values assigned for Acton 9

		CRITERIA					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	10000	20000	0,3	13160	acceptable
		Uhi reduction	3	5	0,6	2,3	good
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	10000	50000	1	15000	acceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	3	good
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.17, Figure 6.18) show the results for the objectives and criteria of Action 9. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

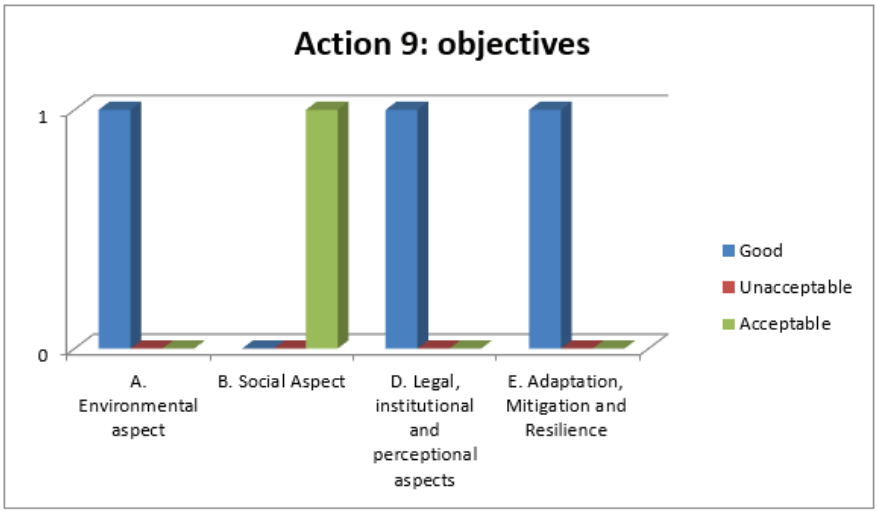


Figure 6.17 DSS results for objectives of Action 9

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.18).

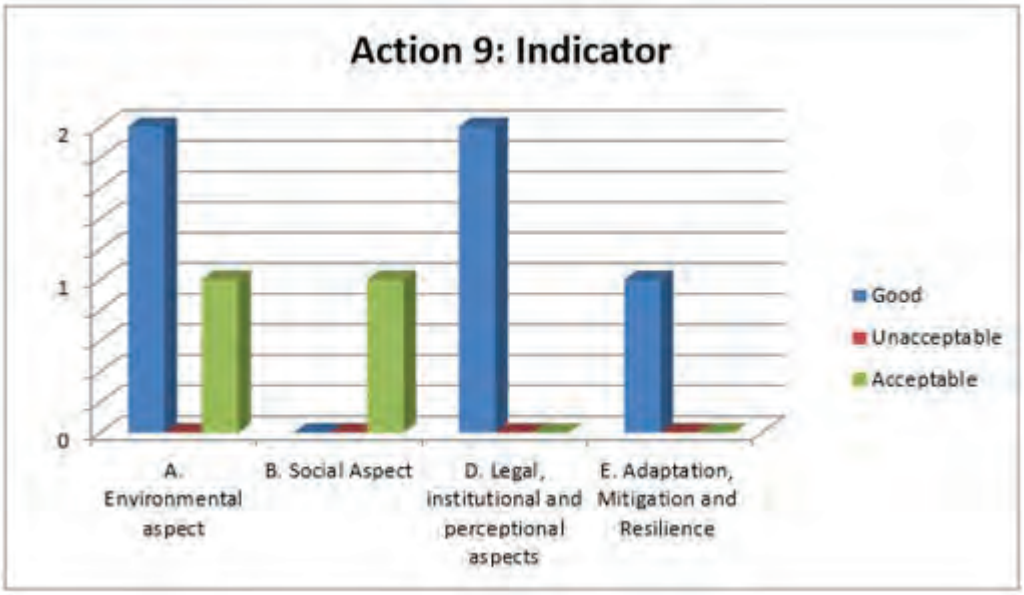


Figure 6.18 DSS results for indicator of Action 9

Based on the analysis of objectives and indicators, Action n°9 was evaluated as *good*.

6.2.10 ACTION EVALUATION n°10 - Green parking spaces with filter strip

The table below (Table 6.10) shows the values assigned to the objectives and indicators of Action 10.

Table 6.10 DSS values assigned for Acton 10

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	2000	5000	0,6	5000	good
		Uhi reduction	2,5	3	0,3	2,3	good
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	30000	100000	1	73000	acceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	3	good
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.19, Figure 6.20) show the results for the objectives and criteria of Action 10. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

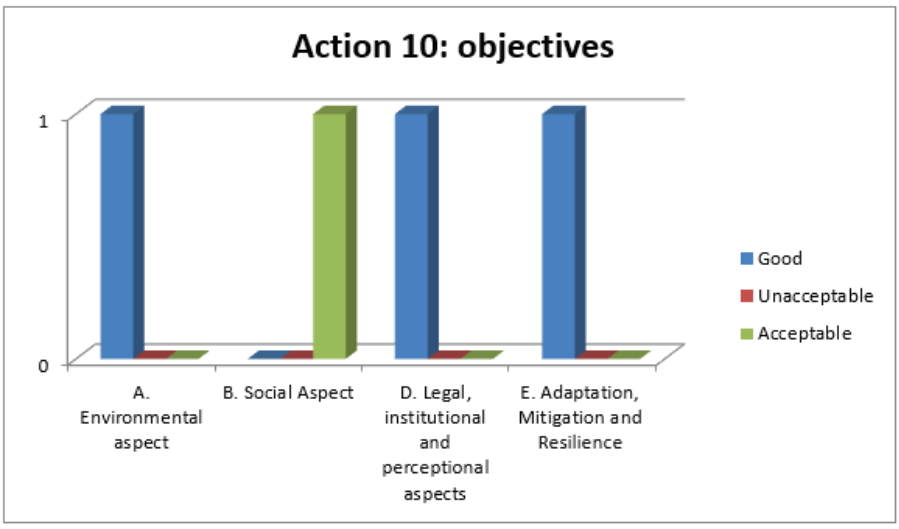


Figure 6.19 DSS results for objectives of Action 10

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.20).

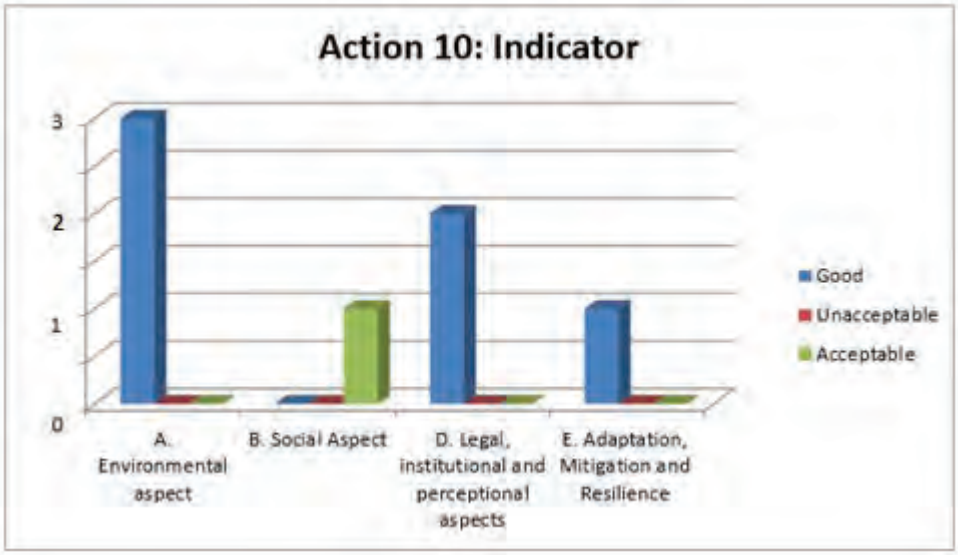


Figure 6.20 DSS results for indicators of Action 10

Based on the analysis of objectives and indicators, Action n°10 was evaluated as *good*.

6.2.11 ACTION EVALUATION n°11 - Green parking lot

The table below (Table 6.11) shows the values assigned to the objectives and indicators of Action 11.

Table 6.11 DSS values assigned for Acton 11

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Good
A. Environmental aspect	0,2	Flooding area	5000	10000	0,3	7000	acceptable
		Uhi reduction	2,5	3	0,6	2,3	good
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,3	People who will benefit from the actions n. Of people)	10000	100000	1	39500	acceptable
D. Legal, institutional and perceptional aspects	0,2	People acceptability	1	3	0,5	3	good
		Political acceptability	1	3	0,5	3	good
E. Adaptation, Mitigation and Resilience	0,3	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.21, Figure 6.22) show the results for the objectives and criteria of Action 9. The objectives in the Environmental aspect group, Legal, institutional and perceptional aspects and Adaptation, Mitigation and Resilience group were evaluated as *good* while the Social aspect group is *acceptable*.

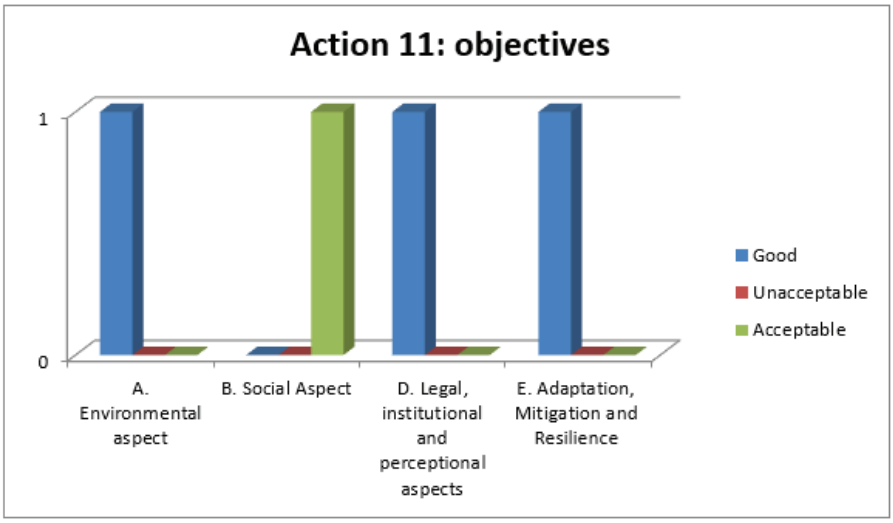


Figure 6.21 DSS results for objectives of Action 11

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.22).

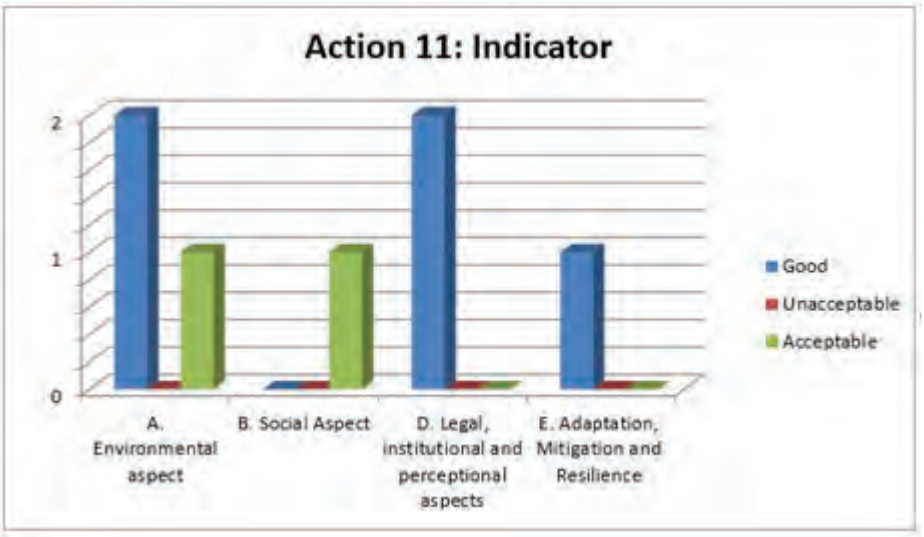


Figure 6.22 DSS results for indicators of Action 11

Based on the analysis of objectives and indicators, Action n°11 was evaluated as *good*.

6.2.12 ACTION EVALUATION n°12 - The mobile barriers

The table below (Table 6.12) shows the values assigned to the objectives and indicators of Action 12.

Table 6.12 DSS values assigned for Acton 11

		INDICATOR					Result
OBJECTIVES	Weight	Indicator	Threshold Min	Threshold Max	Weight (a)	data	Acceptable
A. Environmental aspect	0,1	Flooding area	3000000	5000000	0,4	2250000	unacceptable
		Uhi reduction	0	4	0,5	1	acceptable
		Energy use reduction	0	10	0,1	0	good
B. Social Aspect	0,4	People who will benefit from the actions n. Of people)	40000	100000	1	35000	unacceptable
D. Legal, institutional and perceptional aspects	0,4	People acceptability	1	3	0,3	1	acceptable
		Political acceptability	1	3	0,7	1	acceptable
E. Adaptation, Mitigation and Resilience	0,1	The target of the Action is an area exposed to a Climate Change Impacts and its aim is to reduce the phenomenon.	Not Vulnerable	Vulnerable	1	Vulnerable	good

The graphs below (Figure 6.23, Figure 6.24) show the results for the objectives and criteria of Action 9. The objectives in the Environmental and Legal, institutional and perceptional aspect group were rated as *acceptable*, the Social aspect group is *unacceptable*, while the Adaptation, Mitigation and Resilience group were evaluated as *good*.

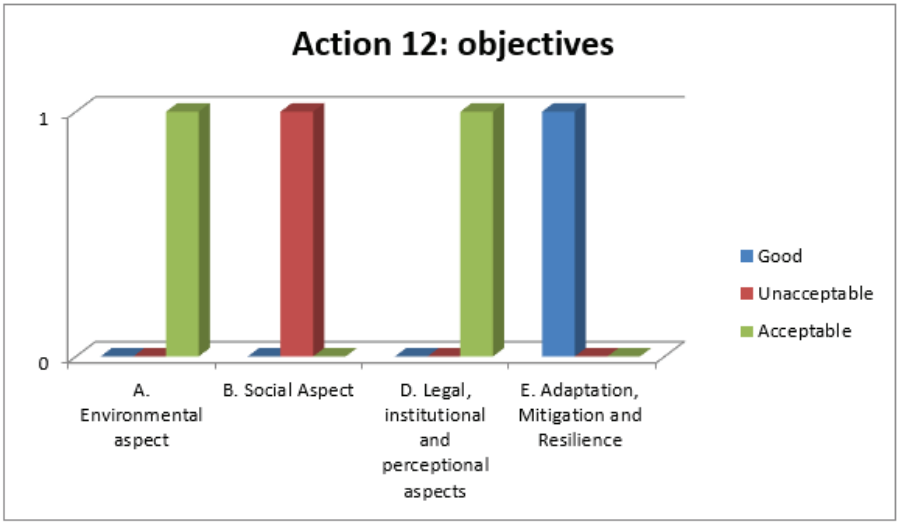


Figure 6.23 DSS results for objectives of Action 12

Within each group of goals, indicators are particularly valuable, and summary results are shown in the graph below (Figure 6.24).

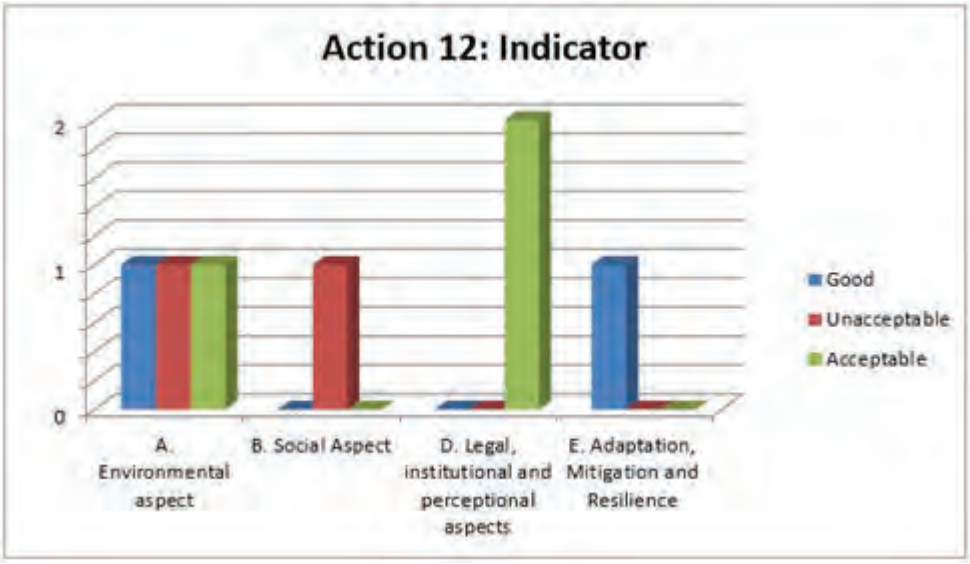


Figure 6.24 DSS results for indicators of Action 12

Based on the analysis of objectives and indicators, Action n°12 was evaluated as *acceptable*.

6.3 Action selected for the implementation

In developing this Plan, a total of 12 climate change adaptation measures were proposed. Of these, 2 measures contribute to reducing the vulnerability of the sea to rising sea levels, 10 measures contribute to mitigating the phenomenon of urban heat island, and 6 measures reduce the vulnerability of areas vulnerable to urban flooding.

Out of 12 measures, 8 were rated as "good" by DSS, one as "acceptable" and one as "unacceptable" (Figure 6.25).

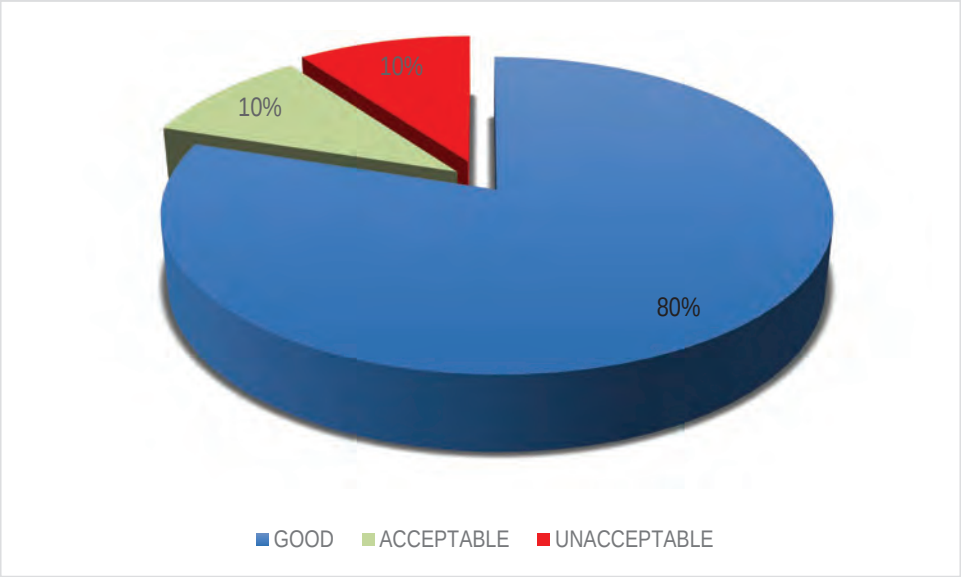


Figure 6.25 Summary of DSS evaluation results

For action that is rated as "unacceptable" (Action n°2), it has been assessed that it doesn't protect sufficient number of people or sufficiently reduce the flooding area and therefore will not be considered any further. Action rated as "acceptable" (Action n°12) were not considered as significant contribution to changing the current state of affairs, i.e. reducing the vulnerability of the City of Dubrovnik to selected climate change, therefore only actions rated as "good" were selected for implementation (Table 6.13).

Table 6.13 A package of actions rated as "good" by DSS analysis

Action n°	Title	Location
1	Parking lots alteration	Dr. Roka Mišetića 2, 20000, Dubrovnik
3	Green roof	Ulica Vladimira Nazora 19, Dubrovnik
4		Ulica Marka Marojice 5, Dubrovnik
5	Natural shading	42°38'45.24"N, 18° 6'7.47"E (WGS 84/UTM zone 33N)
6		42°38'50.64"N, 18° 5'41.01"E (WGS 84/UTM zone 33N)
7		42°38'35.68"N, 18° 6'42.44"E (WGS 84/UTM zone 33N)
8		42°38'32.57"N, 18° 6'41.72"E (WGS 84/UTM zone 33N)
9	Green parking lot	42°38'32.62"N, 18° 6'36.64"E (WGS 84/UTM zone 33N)
10	Green parking spaces with filter strip	42°39'18.44"N, 18°4'41.37"E (WGS 84/UTM zone 33N)

11	Green parking lot	42°38'33.71"N, 18° 6'39.42"E (WGS 84/UTM zone 33N)

7 Monitoring system

Monitoring system allow us to consider how the environmental variables vary based on what has been achieved. Moreover, the monitoring phases allow evaluating, from a quantitative point of view, the effectiveness of the single-action concerning the chosen impacts, whose territory is to be adapted to the negative effects.

In the case of the iDEAL project, it was decided to provide the PPs with a monitoring system specific to their set of identified actions. This system can only be used after the partial or complete implementation of iDEAL actions. This phase helps to understand the results, as well as the achievement of objectives set, through graphs that allow an immediate understanding.

The monitoring system's principle is based on the same algorithms used in the GIS environment to provide the initial impact analysis, while the realization of an easy graphic interface was carried out in excel spreadsheets.

8 Sources of data

http://www.tzdubrovnik.hr/lang/en/get/kratka_povijest_dubrovnika/1601/kratka_povijest_dubrovnika.html
CMHS: http://meteo.hr/
DURA: https://dura.hr/
Environmental protection program of Dubrovnik City
Program for Air Protection, Ozone Layer and Mitigation of Climate Change for Dubrovnik City 2016.-2020.
Program for Air Protection, Ozone Layer and Mitigation of Climate Change for Dubrovnik-neretva County 2017.-2020.
The Sustainable Energy and Climate Action Plan of Dubrovnik City
Strategic plan of the city of Dubrovnik 2018.-2020.
City of Dubrovnik waste management plan
Air Protection Act (O.G. 130/11, 47/14, 61/17, 118/18)