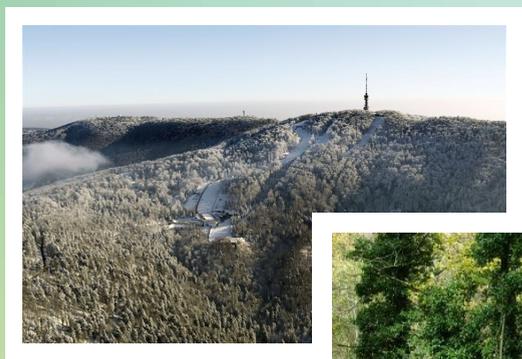


ACTION PLAN FOR CLIMATE CHANGE ADAPTATION

NATURE PARK MEDVEDNICA



MEDVEDNICA

Park prirode
Nature park

IRMO

Institut za razvoj i međunarodne odnose
Institute for Development and International Relations



FOND ZA ZAŠTITU OKOLIŠA I
ENERGETSKU UČINKOVITOST

Action Plan for Climate Change Adaptation

Nature Park Medvednica

Zagreb, June 1, 2017

Project: Climate Change in National Parks and Nature
Parks of the Republic of Croatia: Management and
Development Options

Environmental Protection and Energy Efficiency Fund (FZOIEU)

Institute for Development and International Relations (IRMO)

Publisher:

Institute for Development and International Relations,
Zagreb

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Nature Park Medvednica is a pilot area on the project “Climate Change in National Parks and Nature Parks of the Republic of Croatia: Management and Development Options” developed in cooperation with the Institute for Development and International Relations from Zagreb with the financial support of the Environmental Protection and Energy Efficiency Fund.

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List of abbreviations

NPM	Nature Park Medvednica
PINPM	Public Institution Nature Park Medvednica
CC	Climate change



1. Situation analysis

1.1. Introduction

Medvednica was protected for the first time in 1963 when eight special reserves of forest vegetation were declared, while the Nature Park was declared in 1981 in the area of 22,826 hectares. In February 2009, the Act on Amendments of the Act on the Declaration of Medvednica as a Nature Park the Park's boundaries were amended, and today the surface of the Nature Park is 17,938 hectares. By altering the boundaries of the Park, its surface has been reduced, but the area that has been extremely urbanized has been left out of its former surface, and has not, in its features, fit into a protected nature form and it has not been possible to maintain quality control.

The legal basis for designating a protected area management includes two laws: the Nature Protection Act (Official Gazette 70/05 and 139/08) and the Public Institutions Act (Official Gazette 76/93, Official Gazette No. 22/79, 47/99 and No. 35/08). Nature Park Medvednica is managed by the Public Institution Nature Park Medvednica (PINPM) established by the Government Decree of the Republic of Croatia on 3 September 1998. Since the founder of the Public Institution Nature Park Medvednica is the Government of the Republic of Croatia, its activities have to be aligned with the national legal and subordinate acts of the Republic of Croatia as well as the international obligations of the Republic of Croatia.

1.2. The definition of a key team

The Public Institution Nature Park Medvednica is a public institution operating on the basis of the organizational scheme made of the Office of the Director, the Governing Council and five services. The Nature Park Medvednica is under the jurisdiction of the Ministry of Environmental Protection and Energy of the Republic of Croatia.

In the day-to-day management of the protected area, the Institution cooperates with numerous experts, scientific and state institutions, state enterprises, local and regional self-administration, civil society organizations, regional and

international organizations etc. An important stakeholder in the Park is also the private sector. In the process of obtaining a certificate for sustainable tourism¹, in the beginning of 2013 the Institution founded the Forum of the Nature Park Medvednica stakeholders. The Forum brings together more than 50 different wide-ranging organizations - civil society organizations (from the field of culture, art, nature protection, sport and recreation, hunting societies, voluntary fire brigades, etc.), local self-government (whose important representative is the City of Zagreb), county and city / municipal tourist boards, representatives of the economic sector such as Croatian Forests, hostels from Zagreb, smaller agencies, Hotel Tomislavov dom and Snow Queen Hotel, fifteen smaller catering establishments operating in the Park area, the Croatian Ski Association and many others.

The Park has a diverse regional and international cooperation that promotes the goals of the Institution's activities, exchanges professional experience, participates in project preparation for different EU programs and more. Occasionally volunteers are involved in the activities of the Institution, especially after the launch of various programs at the national level within Croatian Parks, for example "Volunteer in the Park" program for all 19 protected areas.

1 <http://www.europarc.org/nature/european-charter-sustainable-tourism/>

1.3. The establishment of the process

The establishment of the planning and management process in PINPM is regulated by the legislative and institutional framework related to the area of nature protection. It defines competencies for certain aspects of governance, different obligations, dynamics of new adoption, and revision of old documents and strategic plans. The Park's annual activities are defined by the NPM Management Plan (2010), which is made every ten years, and on which the Annual Programs for Protection, Maintenance, Preservation, Promotion and Use of the Nature Park Medvednica are being developed. In order to achieve flexibility in the functioning of PINPM, deviations from the annual plan are allowed in the form of additional activities and projects, since the management of the protected area is also dynamic and subject to various unforeseen events.

One of the basic documents for the preparation of the PPM Management Plan is the Spatial Plan for Areas of Special Features of the Nature Park Medvednica (2014). Spatial plans are also made every ten years. It describes the features of this area, the protection measures and the permitted activities.

The most important strategic document for nature protection is the Strategy and Action Plan for the Protection of Biological

and Landscape Diversity of the Republic of Croatia (NSAP, 2008). A second generation of the strategy is currently being prepared for adoption.

Climate change is not addressed in the institutional documents of the PINPM. Thus, the Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia (2008) mentions it only marginally. The Nature Protection Act is also not concerned with climate change. At national level, a Climate Change Adjustment Strategy is being developed only now whose implementation is expected by the end of 2017.

The new document of the Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia (2015) also includes more extensive strategic guidelines on climate change. Only after the introduction of climate change topics into basic legal documents and legal and subordinate acts relevant to the PINPM it will be possible to establish processes that will further support and encourage research into climate change impacts on the Park and ensure flexibility in decision-making and planning of activities related to this topic.

In 2015 for the first time in Croatia the Climate Change Adjustment Plan of the City of Zagreb was developed. The plan analyses the impact of climate change on social,

economic and environmental aspects of the development of a single urban environment. The development of the Plan was initiated by the City Office for Energy, Environmental Protection and Sustainable Development. The Adjustment Plan did not cover areas within the boundaries of the PPM.

The implementation of new processes in the Nature Park does not depend solely on the Public Institution. This is best seen in the example of forest management. Forest management in the Park is carried out by Croatian Forests (for state-owned forests), the Faculty of Forestry (for the Faculty of Forestry forests) and private owners. Thanks to the protection of this area as a nature park, Croatian Forests implement forest management in a way that supports the greatest biodiversity of this area, and the mechanism by which this is achieved is determined by the nature conservation conditions that are built into the forest management principle. Regular field and cabinet coordination and data exchange are also carried out. Private owners, over 12,000 just in the south part of the Park area, as well as the return of forestland to private landowners and the Church, represent a challenge in forest management, and these processes still need to be harmonized and improved by the use of forests. Unfortunately, such a twisted management system is very flexible and tricky as it involves a large number of different services. In order to implement a new process in such a system, different regulations and institutional

documents, i.e. the procedures they require, must be respected. This means that it is not enough to make changes to core management documents and PINPM strategies, but adaptation to climate change should also be incorporated in other sectors that operate in the Park. Similar problems arise in other areas such as water management (Croatian waters), road infrastructure (each county has its own road maintenance service), emergencies management, etc.

In addition to stormy weather and windsurfing in the period 2013-2014, in the Nature Park Medvednica in the beginning, there was some confusion among the stakeholders and chaos in the field and also some stakeholders were exposed to the dangers (firefighters, foresters, and employees of the PINPM). An example could be the closure and opening of the county road for traffic due to wind-defatted trees that had no defined protocol. The protocol for informing the public about the situation in the Park was also not defined, but the information came from a variety of sources that caused confusion. Furthermore, the consequences of the storms were also noted on infrastructure (traffic, communal, visitor) – no stakeholder had any financially available funds for emergencies (the procurement and licensing processes should be more flexible), therefore the damage elimination is still carried out today at certain locations, for example on the slides of the county road. Due to all the above mentioned, there is a great influence of certain stakeholders to economic activity in the Park.

1.4. Assessment of human and financial resources and funding opportunities

1.4.1. Human resources

PINPM employees belong to different professional profiles. At the moment, an interdisciplinary staff is employed in the NPM: biologists, foresters, economists, geographers, geologists, workers with secondary education and unskilled workers. This structure of employees allows a greater level of holistic view of space and facilitates the Park's management. The natural and biotechnical orientations of the Park's employees are a good precondition for a deeper understanding of climate change issues and the quality implementation of adaptation measures, but they require quality trainings and continuous improvement. In addition to quality education and trainings, the problem is the lack of employees in the Park and their continuous fluctuation.

The Park currently has 16 employees, of which 15 are funded from the State Budget, while one person is funded from the Park's own revenues. Depending on available means, the Park occasionally engages honorary associates during the tourist season, while preparing more extensive projects or some other activities that require external engagement.

Unfortunately, even in its primary function, the Park is severely short of employees, which is especially evident when trying to implement some additional projects. For normal functioning of the Park the estimated number of employees should be about 50.

The quality implementation of the adjustment measures and the ability of the Park to react quickly to changes in space will primarily depend on the capacity of the Park, as well as on the good vertical and horizontal networking and communication of all stakeholders of the Park.

1.4.2. Financial resources and funding opportunities

PINPM is funded from three different sources. Since the Government of the Republic of Croatia is the founder of the Public Institution, each year the State Budget allocates funds for the work of the Institution, which performs basic activities related to the protection, evaluation and preservation of natural and cultural values, the promotion of natural and cultural heritage, the development of sustainable tourism, etc. The Public Institution has its own revenues, thanks to its offers that are not exclusively related to nature protection, such as ticket sales for three tourist attractions, souvenir sale, concession permits, educational and tourist programs. The third source of income are various donations, sponsorships and projects funded through the programs and funds of the European Union.

If we analyse the long-term financial situation in the PINPM, it is apparent that the revenues from the state budget are reduced, which has a negative impact on the various spheres of the Park management. Thus, less is invested in research, protection activities, EU project preparation, the number of external associates decreases, and the number of staff financed through the state budget funds is also lower, which consequently burdens the quality of work, i.e. the implementation of all activities.

The Park's own revenue varies depending on numerous factors related to its functioning, such as weather conditions affecting the visits to certain sites and manifestations in the Park and the temporary closure of the most visited sites due to the protection of the fauna, the implementation of works, the impossibility of work, etc. Significant variations in the visits occur in certain years when hemorrhagic fever virus infection occurs on Medvednica. Due to media images about epidemic proportions of this virus, the number of visitors to the three most important sites in the Park, as well as in catering and tourist facilities, decreases. Despite the high attendance, (surveys show that the NP has more than 1 million visitors per year), it is not yet planned to charge entry tickets to the Park. There is a policy that with the majority of domestic visitors the entrance to the Park is not charged; i.e. only the contents and services are charged, which is in accordance with the institution that this description determines the most.

Revenues from donations, sponsorships and various projects depend on different external factors. Donations and sponsorships are mainly related to the organization of certain events in the Park's area or to the renovation of smaller infrastructure elements. The projects are thematically oriented and their financial weight varies greatly. The largest project funds are received through large projects funded from the EU funds (programs and funds).

So far, the Park has not allocated special funds in the context of investment in research related to climate change, the risks associated with them, measures to adapt and mitigate them. A very brief overview of the impacts of climate change is presented in the publication "Pressure and Threat Analysis in the Nature Park Medvednica" (HAOP, 2015: pp. 52-55). The scope of this analysis has in fact only indicated that there are grounded indications of climate change impacts on the Park and this document can be considered as an introduction to further research and definition of measures.

With regard to funding opportunities for future projects that will be focused on research, development and implementation of mitigation measures and adaptation to climate change, currently there are no planned financial means for such activities within the Park. Therefore, as potential sources of funding the following can be considered: additional sources from the state budget and project funds. The Park's own resources are insufficient to adapt to climate change.

1.5. Data collection

The Nature Park Medvednica is located on an area that has been inhabited for centuries and is deeply permeated by the influence of human activity. The continuous presence of man has left many traces in the area, but also in various written documents that can give us valuable information about Medvednica.

Today's research and different data collection on Medvednica is carried out, apart from the PINPM, by various professional and scientific institutions, civil society organizations, business entities active in the Park, and occasionally ordinary citizens through volunteering associations and programs (e.g. through the reporting system of the Croatian Agency's for Environmental and Nature Protection on the population of deer).

1.5.1. Biodiversity

Medvednica has always attracted a large number of researchers. Most of the research was carried out by independent Croatian and, to a lesser extent, by foreign researchers and most of the faculties of the University of Zagreb. The largest number of references refers to non-continuous research while some of the older references have

been lost. It can be said that the Nature Park Medvednica is one of the most prominent protected areas in Croatia, which was significantly contributed by the close proximity of urban environments and a major university, and later the efforts of the PINPM to support scientists and experts of different orientations in their research.

Only with the establishment of the PINPM a continuous and systematic collection of data and literature on the values of Medvednica was initiated. PINPM also launches a number of biodiversity inventories (e.g. flora, birds, butterflies, bats, cave fauna, etc.) to get recent data on present species and habitats. A component of inventory was also a comparison of field findings with literary data. This method of analysis has provided valuable data suggesting changes in species composition that include the appearance of new species, the absence of previously recorded species and the change in their number. Unfortunately, inventory projects are very limited in terms of scope and duration, so there is a need for caution in the interpretation of such data. Selected species and habitats are monitored by monitoring protocols and these data can be considered as more credible indicators.

The area of NPM is characterized by a very large number of recorded species, many of which are categorized according to IUCN categories and classified in the red list of threatened species and a number of strictly protected species according

to the regulations of the Republic of Croatia².

NPM habitats were mapped in 2007 (Nature Park Medvednica Habitat Maps (M 1:25 000), OIKON) and these data can be considered as a representative starting point when it comes to their spread and detailed presentation.

1.5.2. Ecological network of the Republic of Croatia

The entire area of the Nature Park was declared a Natura 2000 site under code HR2000583 as a conservation area important for species and habitat types (POVS). These are areas of importance for the conservation and exploitation of the favourable status of wild species and their habitats, as well as natural habitat types of interest for the European Union. The Natura 2000 network is also aligned with the National Ecological Network of the Republic of Croatia. One of the obligations of the Republic of Croatia towards the European Commission is regular reporting on the status of Natura 2000 sites. Therefore, the Park performs monitoring of the target species according to the planned dynamics that is in line with the financial resources of the Park to monitor the state of their populations. Unfortunately, there are still no elaborate monitoring plans for all target species as well

2 [http://www.dzrp.hr/vrste/crveni-popis-biljaka-i-zivotinja-rh/crveni-popis-biljaka-i-zivotinja-republike-hrvatske-146.html#Crveni popis](http://www.dzrp.hr/vrste/crveni-popis-biljaka-i-zivotinja-rh/crveni-popis-biljaka-i-zivotinja-republike-hrvatske-146.html#Crveni%20popis)

as for target habitats, so the collected data are still not complete. This applies in particular to target habitat types. Previous monitors did not specifically address the issue of climate change impacts on target species and habitats.

1.5.3. Forests

Of the total area of the Nature Park Medvednica (17,938 ha) forest habitats occupy most of the area (81%). The state forest area is 8,195 ha and private 5,988 ha (41%), while 374 ha is owned by the Faculty of Forestry and is intended for research. Representation of particular forest communities is shown below (Figure 1).

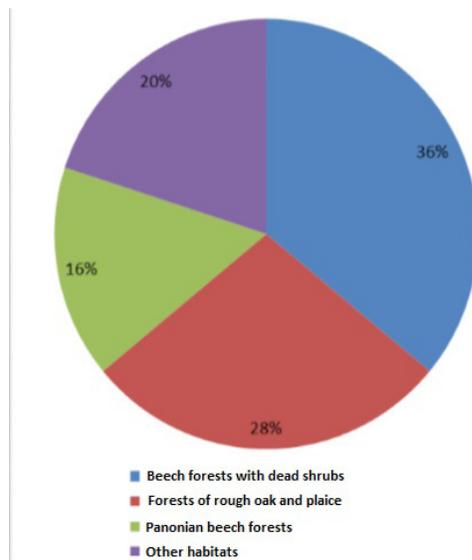


Figure 1: Representation of forest communities in Medvednica (Source: PINPM database)

State forests

Although the Public Institution “Nature Park Medvednica” manages this area, it is in fact the company Croatian Forests, as a state institution, which is directly responsible for the management of forests in the area of state forests. The form of management applied in the area of Medvednica is the active management of forests for the purpose of exploiting wood mass with multiple restrictions related to increasing biodiversity and recreational function. Eight special forest vegetation reserves are excluded from this form of management, in which only operations and activities to maintain or improve the conditions important for the preservation of the properties for which they are declared to be reserved are carried out.

Private forests

A total of 41% of forest areas are privately owned. The average size of the private property (forest particle) is about 0.3 ha. The number of owners is about 20,000. It is also very common that one particle has multiple owners (3 or more). Until the past ten years there was only one association of forest owners on Medvednica named “Kulmerica” who planned to manage forests of forest owners on the surface of about 230 ha, i.e. on 4% of the surface. On the other 96%

of the area, the management was not planned, that is, every forest owner managed it himself. Croatian Forests, as a state enterprise, provided expert assistance in the management to forest owners. The new Forest Law of 2005 stipulates the establishment of a “Forestry Advisory Service” which has the task of taking over the organization and implementation of the management of privately owned forests. Then systematic inventory of the entire area of Medvednica private forests began, based on which they were divided into ten management units. Forest management programs for private forest owners are the basic document based on which the forests are managed by forest owners. It consists of information on forest status, management objectives, type and scope of the works, and the regulations and methods for achieving set management objectives. The Advisory Service carries out public tenders for their development, whereby the development is entrusted to the licensed contractors with the regular office and field quality control of the performed works by forestry experts, Advisory Services employees. During the development of the Management Program, the Advisory Service with the contractor organizes introductory lectures, public insights and debates where forest owners from the area covered by the Program have the opportunity to gain basic understanding of the way the Management Program is drawn up and become acquainted with its significance in the forest management. The programs are approved by the Ministry of Agriculture, after which the

forests covered by the Program are managed according to the management guidelines stipulated in the Program.

Since it is difficult to talk about long-term planning because forest ecosystems are in dynamic balance and constantly subject to changes, which are necessary, to adapt, programs go through audit procedures and reconstruction.

Funding of the development of Forest Management Program for private forest owners is carried out from the Fund generally useful functions of forests. For each economic unit, a “Forest Management Program for Forest Owners Management of the Economic Unit” was developed.

State incentives in forestry have been introduced, but as a prerequisite for any form of financing, the forests must have established and approved the Forest Owners Management Program and be entered in the Register of Forest Owners. It initiated forest owners to join the forestry association. In the area of Zagreb County and the City of Zagreb there are the following private forest owners’ associations in the area of activity of Medvednica: “Zagrebačka gora” Forestry Association, Forestry Association “Žir” Zagreb and Forestry Association “Medvedgrad”.

The problems related to nature conservation (conservation of biodiversity) in private forests are related to:

- lack of forest owner education on the importance and value of biodiversity, Natura 2000 species and habitats, the benefits provided by the protected area;
- lack of data or difficult access to data on protected species;
- poor functioning or absence of forest owners' compensation mechanisms;
- illegal and / or over-exploitation of forests;
- foreign and invasive species of trees and shrubs.

The status of forest stands has been monitored since 2008 within the project “Monitoring of the Forest Ecosystems of Medvednica Nature Park” financed by the PINPM and implemented by the Institute for Forestry in Jastrebarsko. The project then continued through various other monitoring projects of forest stands that were implemented by the same institution and similar activities are still going on in 2017. Projects like this have continuously collected information that can be used to track changes in forest communities.

1.5.4. Other habitats

Areas in the park that are not covered by forests occupy a small part of the area (19%). They are made by different lawns, orchards and vineyards, hedges, shrubs etc. (Figure 2). The importance of these areas is very significant since they

represent important habitats of many rare and endangered plant, animal and fungal species. Lawns are rare within the forest complex, while in the periphery they extend to larger areas, they are often intertwined with woods and vegetation of shrubbery. Numerous ecotones are formed in contact with vegetation on forest edges. Non-forest vegetation is mainly anthropogenic origin. Due to the abandonment of traditional use of space such as grazing and mowing, successive vegetation has been developed in the form of shrubs and forests. This loses the landscape and biodiversity of the Park, especially on grassy types that are habitats of endangered and rare plant species.

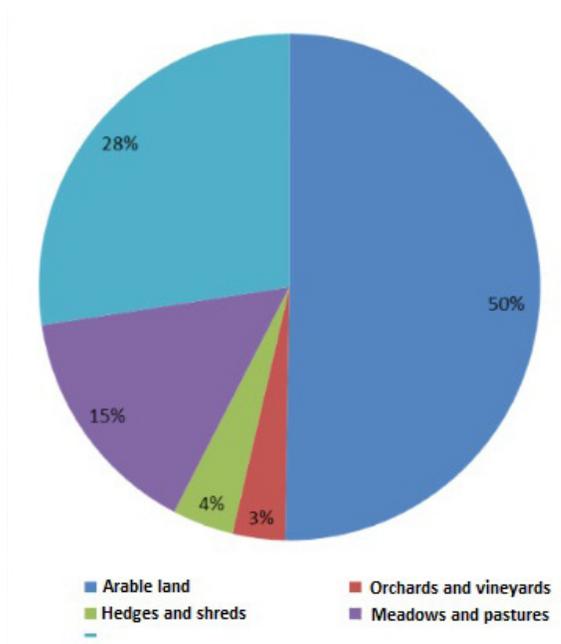


Figure 2: The composition of non-forest area on Medvednica (Source: PINPM database)

Among important non-forest habitats stand out numerous streams, small lake aquatic habitats and underground karst habitats. Streams of water and lower shapes of water such as different pools and pool habitats are a habitat for a large number of aquatic organisms. Among them are the various amphibians and insect larvae, which are among the most important bio-indicators. Because of its geomorphology (small, fast and shallow watercourses), Medvednica streams support a very small number of fish species.

The existence of dolomitic-limestone geological substrates enabled the formation of a relatively large number of karstic caves. Among them, the Veternica cave stands out because of its size and biodiversity and which has been subject to constant monitoring since 2005, which includes the cave microclimate monitoring, and these data can be used as extremely valuable indicators of changes in space.

1.5.5. Protection zones in the Park

The Nature Park Medvednica is divided into three spatial-planning zones: Zone I, Zone II and Zone III. The area is defined based on the biological, geological, cultural and traditional characteristics of space, and when defining it, the pre-use of space and management needs have been taken into account. By categorizing the individual zones, permitted human activities in a given area are described, which are

consistent with nature conservation objectives. Detailed zoning information in the Park is defined by the Spatial Plan (2014). The Park Area is significant when we talk about the context of climate change since each zone has specific characteristics that are exposed to particular risks.

Zone I: Strict Protection Zone

The strict protection zone is protected by areas of great value whose preservation is of utmost importance. There is no intervention in the space or possibly only minimal interventions (e.g. invasive species removal, fire localization, etc.). This zone includes all parts of the Nature Park which, by their characteristics, represent the particular or most valuable (biodiversity, landscape value, ecological role, alone or as part of a system) or a typical natural occurrence within a particular type of habitat. In the area of the Nature Park Medvednica in the strict protection zone, limited and controlled visits are permitted.

Zone II: Active Protection Zone

The second zone protects special forest vegetation reserves where significant engagement is needed to preserve or regenerate the value of that area. These are all areas that would have changed their characteristics without active management, but also areas where the local population and other stakeholders use natural resources. This zone

includes: forest systems, which are actively, managed, special forest reserves, meadow areas including Faculty area and abandoned quarries. Activities permitted in this area are aimed at interventions for the conservation, maintenance and improvement of specific ecosystems, the improvement and development of a visiting system with minimal impact on habitats and the use of natural resources.

In a special sub-zone of active protection, areas of intense visits and more demarcated visitor infrastructure and visitor content are included. This area covers the wider area of the peak zone and meadows used as ski resorts. Managing this area requires increased efforts to manage visitors and intensify research with the purpose of planning the use of space. With the purpose of preserving, maintaining and enhancing specific ecosystems, the permitted activities are directed towards the development of a sustainable, safe and attractive visitor system that does not endanger the protection objectives and promotes the value of the Park.

Zone III: The Use Zone

The third zone includes areas where a form of use has traditionally been in place or have a lower conservation value. They are mainly managed for some other purpose important for the function and development of the protected area and represent a kind of compromise between the use and

protection of space. Therefore, the use must be in accordance with the principles of sustainable development in a way that does not undermine the purpose of the protected area. Areas characterized by high environmental pressure due to the planned development of the settlements are subdivided into sub-zone IIIa. This zone also acts as a buffer zone between the forest complex and the more intense urbanized areas that surround the Park.

The quarries which are still being exploited are located in zone IIIb. Activities in this area are aimed at remediation of quarries. Tourist infrastructure located within zones 1 and 2 also belongs in the use area. These are mountain lodges and other solid objects, asphalted and forest roads.

The zone system is not static, and as soon as more data is available, it is possible to change it when the new spatial plan is made.

1.6. Communication and dissemination of data

The Nature Park Medvednica has a prominent position in the protected area system both at national and regional level. Due to its specific geographic position, the Park is surrounded by nearly a quarter of the population of Croatia.

The proximity of the capital and the large number of visitors also contribute to its media exposure.

Depending on the form of information they want to convey to the specific target audience, various forms of communication are used.

1.6.1. Websites and social networks

PINPM has its own website where it regularly publishes relevant information about the Park Events, projects, important dates, etc. It also actively participates in social networks such as Facebook and Instagram. Electronic forms of communication are very well received by visitors to the Park, therefore there is a large number of visits to its websites. The most media tracking takes place via the web, Facebook and Instagram, websites of Nature Park Medvednica and Experience Nature Park Medvednica, during major events in the Park that take place fifteen times a year.

At the national level, there is the communication between the brand of Croatian Parks and social networks. Regionally, within the WWF project “Protected Areas for Nature and People”, communication takes place via the web and Facebook “Dinarid Parks” in eight countries.

1.6.2. Media

Communication with the in the Nature Park Medvednica is satisfactory and is a common way to disseminate information about projects and activities that take place in the Park area. PINPM has extensive experience with various audio-visual and printed media monitoring.

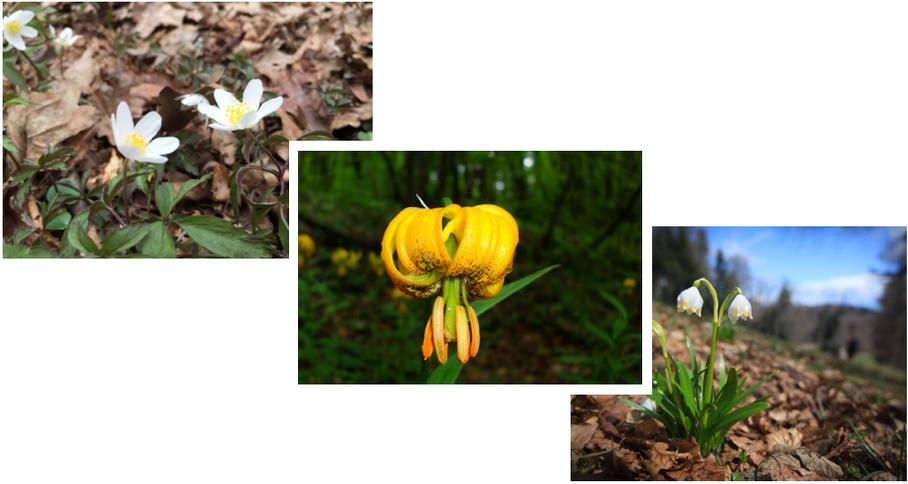
1.6.3. Stakeholders' Forum

The NPM stakeholders' forum is a very important platform for disseminating information that is relevant to the Park's area. It is made by public institutions that manage some of the Park's segments (e.g. representatives of Croatian Forests, Croatian Waters), private landowners, hunters, researchers etc. The purpose of the Forum is to facilitate sharing of information with stakeholders, to facilitate knowledge transfer, to encourage discussion of current problems and to try to solve them, but also educate stakeholders on topics relevant to the Nature Park Medvednica.

1.6.4. Education, manifestations, tourism

PINPM as part of its activities, organizes a large number of educational programs and professional guidance for children, young people and adults who promote the

protection of nature. Users of education activities are mainly members of the younger population, while different cultural manifestations are visited by mixed populations. The Park has developed professional guidance within three tourist attractions, elementary school educational programs that are in line with the school curriculum and fifteen traditional cultural, tourist, recreational sports events as well as events marking important dates in the area of nature protection. Throughout the programs of the PINPM there are about 30,000 users annually, and recently, since the introduction of Medvedgrad in the offer, the share of foreign tourists has increased.



2. Risk and vulnerability of the natural park Medvednica

This chapter identifies existing and expected risks related to climate change and the ability to adapt and / or strengthen resistance. Information on risks and vulnerabilities is important for determining climate and other (socioeconomic) effects on the basis of European and national projections. These analyses are a framework for defining indicators that are measurable, easy to follow and interpret (e.g. enable identification of key vulnerable points, raising population awareness of the consequences of climate change, etc.). Some of the clear and measurable indicators are, for example, the availability of water, forests and their growth, flooding, biodiversity and so on.

Climate change projections have been explored in the world, including in Croatia, with the help of a large number of global and regional climatic models. Although the general trends of most models are very similar and around them, there is an international consensus, it is still not possible to estimate the intensity of certain changes and their precision on smaller scale since regional deviations are possible due to the large number of variables that can create local anomalies.

In order to clarify the local impact of climate change, it is important to make targeted analyses of available information on the area. Literature data (e.g. research, historical records, etc.), long-term measurements at or near the locality (e.g. temperature, precipitation and flow) can be used for this purpose. Although, when we talk about climate change, we mostly mention their future influence, but we can actually track them in the past decades. Their influence has already begun to manifest in all parts of the earth. It is therefore important to take into account all available data and impacts that could be linked to climate change.

The results of the Sixth National Report of the Republic of Croatia which are in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) are an important source of general data for the Republic of Croatia by which trends and their relative impact can be traced in different regions. However, for local impact clarification, a

particularly important source of data are local measurements by which more accurate data can be obtained that can be applied to the development of further climate change strategies.

According to projections of the future impacts of climate change that can be related to Medvednica and are consistent with the accepted impacts in most professional and scientific literature, the following risks can be distinguished:

- Temperature
 - increase in mean annual temperature
 - increasing the frequency of occurrence and the value of extreme summer temperatures
- Rain and wind
 - an uneven distribution of precipitation
 - the phenomenon of extremely abundant short-term strong precipitation
 - reduction of snow cover
 - extremely powerful storm winds
 - ice
- Hydrological influences
 - trend of reducing the flow of streams on Medvednica
 - torrential flows as a result of extremely heavy rainfall
 - activation of landslides as a result of periods with abundant precipitation

- Fires
 - extremely dry periods, especially in combination with high temperatures and wind, can affect the risk of increased fire, its rapid spread and the scale of the affected area.

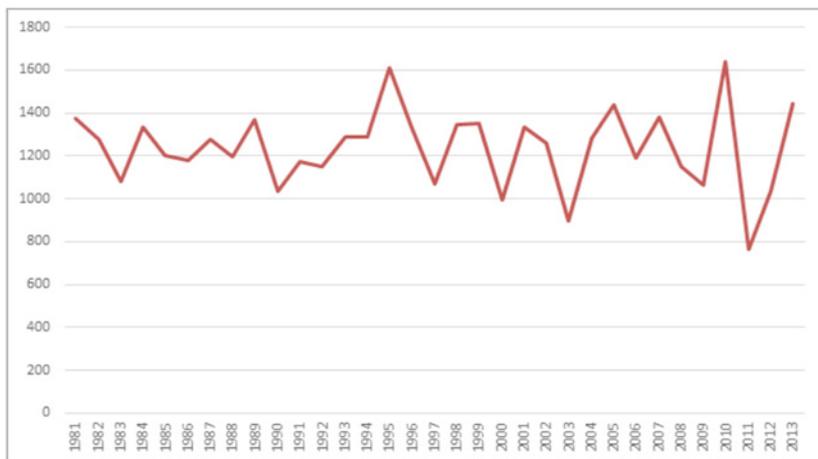
Due to the specifics of the various components of the Park, the risk and vulnerability assessment was considered for components estimated to be significantly affected by climate change, and the intensity of impact was assessed by means of a scale ranging from low, medium to high risk.

2.1. Current knowledge about risks and vulnerabilities in the area NPM

Climatological measurements on Medvednica began in 1888. Today in the Nature Park there are several pluviometry stations on the southern slopes near the city of Zagreb: Čučerje, Markuševac, Šestine, Mikulići and Bijenik, the highest of which is at Puntijarka, at 988 m above sea level. Although such a large number of measuring stations and long-term measurements are valuable data, no systematic research on climate change has been made so far. However, occurrences such as an increase in average air temperature, changes in rainfall quantity and extreme weather conditions are attributed to climate change. Particularly high risk for

Medvednica are storms with an emphasis on storms with storm wind.

Once in 2013 and on several occasions in 2014, there was a stormy weather with wind on Medvednica that caused great damage to the forest habitats. The recorded wind blows had a speed of up to 150 km/h, which was not typical for these areas, and very high rainfall occurred along the storm. According to the Danger Categorization in the Document “The Pressure and Threat Analysis in the Nature Park Medvednica” (2015) storms with snow and ice represent a medium strength of threat, while floods and rising precipitation represent a low strength of threats for NP Medvednica. Changes in biotic conditions are characterized as medium pressure in the Use Zone due to large human influences on the number of populations of endangered species. Migration of species, drought and changes in precipitation and temperature are characterized as low pressure. The annual amount of rainfall in the Park area is about constant (about 1200 mm), but the extremes between individual years are increasing (Figure 3).



Slika 19: Padaline za razdoblje 1981. – 2013.

Figure 3: Average annual precipitations for the period 1981 - 2013 at the Puntijarka measuring station (source: Analysis of pressures and threats in the Nature Park Medvednica, Zagreb: HAOP, 2015.)

Significant figures in the context of climate change represent average air temperatures for January and August in the period 1981-2013 at the Puntijarka measuring station because they point to a significant upward trend (Figure 4 and 5).

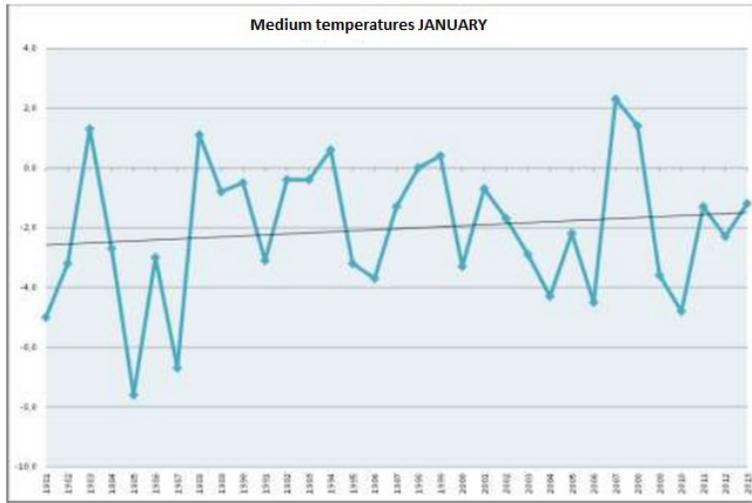


Figure 4: Average annual temperatures in January for the period 1981 - 2013 at the Puntijarka measuring station (source: Analysis of pressures and threats in the Nature Park Medvednica, Zagreb: HAOP, 2015.)

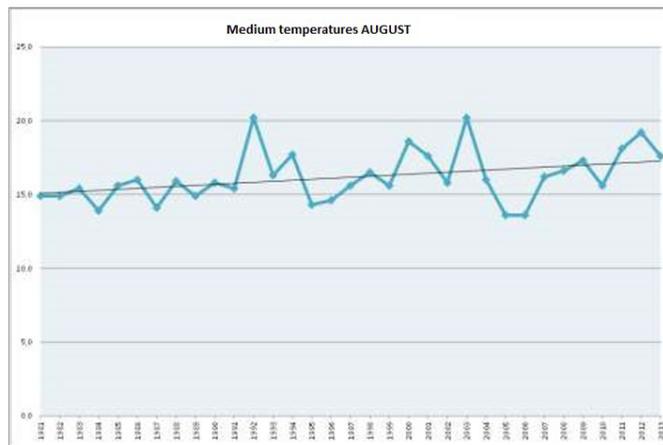


Figure 5: Average annual temperatures in August for the period 1981 - 2013 at the Puntijarka measuring station (source: Analysis of pressures and threats in the Nature Park Medvednica, Zagreb: HAOP, 2015.)

2.2. Risk and vulnerability assessment for species and habitats in the context of climate change

The general impact of climate change on living organisms is difficult to imagine since each species has a specific sensitivity to ecological factors. Due to the comprehensive link between all members of the ecosystem, but also the biosphere as a whole, it can be concluded that all organisms will in some way be influenced by climate change. It is possible to expect the change of individuals in the populations, and their number will vary in favour of the species that have the best ability to adapt to the changes, i.e. the occurrence of extreme conditions. The species of small populations are often referred to as the most sensitive species. The end result of the change in the number of individuals in the population can be their total disappearance in a habitat (whether it is extinction or alteration of the area), but also the settlement of new species adapted to newly emerged conditions. One of the answers to the changes can be migration of the organisms, if possible. Ecosystem disorders will increase the risk of spreading invasive species. In order to fully assess the risk of climate change impacts on natural constituents, these impacts are considered by monitoring the impacts on specific habitats.

2.2.1. Forest stands

Forest stands are the fundamental phenomenon of the Park and cover about 81% of the surface. Forest vegetation consists of diverse forest communities, which is evidence of the great heterogeneity of this area. The current state of forest stands has been damaged as a consequence of air pollution in the central part of Medvednica and the intense use of space and many other negative factors. The most intense negative impact manifested itself in the peak area of the central part of Medvednica, which is also the most intensively used, and damage is more intensive on the southern slope of Medvednica as a result of pollution coming from the City of Zagreb. A worrying trend is in private forests that are of less quality than those of the state, which are very fragmented, with many owners and with inadequate control mechanism. Nearly 1.2 million people exert pressure on the entire area with regard to the different types of use: sports recreational, educational, cultural tourism, and in private forests in the perimeter belt also illegal activities occur - illegal logging, quarrying, waste disposal. The results of field research and field observations indicate that the most varied types of oak rootstock, tannic chestnut and fir are drying. This form of drying shows many similarities with the drying of forests throughout North America and Europe. However, there is also a decay in species with no observed symptoms of drying (sessile oak, oak, downy, holm oak, sycamore maple, hornbeam, etc.).

Vegetation shift. Forest stands in the Nature Park Medvednica show a distinct zone that is due to the altitude and exposure that determine the climatic characteristics of individual vegetation zones. Increasing the mean annual air temperature, precipitation and drying will influence the potential distribution of individual vegetation zones. Since stern plants have very slow growth and are slow to spread, this impact will have a delayed response in time. It can primarily be expected that vegetation located in the shift zone can be exposed to stress conditions that will reduce their viability. Replacing the vegetation cover towards the new vegetation zone boundaries will be a very slow process. The expected response to the new conditions will not be the same in all species but will first be reflected on species that will be under the most intense stress-specific influences specific to individual species. Level of risk: high.

Changes in species composition. Increasing the mean annual temperatures and the early melting of the snow cover will affect the beginning and the end of the vegetation season. This can affect the vegetative growth in such a way that some stern plants that are under minor stress conditions can achieve more intense growth. The difference in the ability to exploit favourable conditions can lead to changes in the dominance of the species. A significant increase is expected in the species that will be in zones that will have optimal precipitation levels.

Changes in domination will also be reflected in drought resistance. Species that are more tolerant to dry periods will have a higher intake than those that are sensitive to droughts. These changes have a complex cause-effect relationships. Therefore, a more intense growth may have the effect of overshadowing adjacent trees, thus providing a more competitive advantage to a more resistant type. Level of risk: high.

Animal areal. Changing the microclimate conditions in Medvednica in zones where vegetation will change will also affect animals. Because of their ability to move, it is expected that their change of area will happen much faster than changes in plant species (mostly woody plants). Level of risk: high.

Pollution of the atmosphere. Medvednica is under the influence of local and regional sources of atmospheric air pollution. Although climate changes will not directly affect the level of pollution, the synergistic effects of extreme dry periods combined with the pollution of the atmosphere may intensify the stressor effect of vegetation sensitive to air pollution. Degree of risk: medium high.

Forest pests, phytopathogens (fungi, bacteria, viruses), the plant parasite. The presence of forest pests (e.g. rootstocks, oak hornbeam) is an integral part of the

forest ecology. Pests populations are controlled by a large number of factors, especially low winter temperatures.

If the forest habitat is not exposed to the optimal number of cold days, the pests can create large populations, which pose significant threat to the forest stands. Decline in forest stands as a result of stress conditions (e.g. drought) favours the spread of phytopathogenic diseases and the intensity of damage. Therefore, it can be expected that the intensity of these diseases will be increased, and their area may be expanded. Level of risk: high.

Small forest rodents. Small forest rodents are also sensitive to winter temperatures. In the absence of an optimal number of days with low temperatures, their populations are rapidly growing, reflecting on other nutrition nets, but also significantly increases the risk of transmission of hemorrhagic fever virus. Level of risk: high.

Invasive organisms. Invasive organisms most easily establish their populations in natural habitats that are degraded, exposed to stress or are anthropogenically altered. In such habitats, invasive organisms have the potential of very rapid and successful dissemination. Due to changes in average annual temperatures, it is expected that the area of invasive species also spread to higher altitudes. Degree of risk: medium high.

Weather extremes (storms and heavy rainfall). Storms accompanied by strong winds, if they exceed the usual limit of tolerance of the present vegetation, can cause devastating damage to the forest cover. In addition to the partial destruction of trees, the probability of extracting single trees that are less resistant to these phenomena is increased. With the fall of the trees, a cascade reaction occurs where the fallen trees during dredging destabilize adjacent trees. This strengthens the intensity of the damage that expands to stable trees that would otherwise not have been extracted. Level of risk: high.

Ice breaking, overturning of ice and snow. The ice that occurs as a result of ice rains, especially if it is present in larger quantities and goes on for days, creates devastating consequences on forest stands, as it was visible in 2014 in the forests of Gorski kotar. Ice creates multiple damage to trees (ice breaking), and due to changes in statics, the trees can be cut off (overturning of ice). The consequences of ice breaking have a long-term impact on forest stands. Overturning of snow occurs if the static stability of the trees is disturbed due to the large amount of snow cover. These damages are of less intensity than the consequences of the ice breaking or overturning of ice. Level of risk: high.

Table 1: Types and levels of risk for forest stands

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Vegetation shift	Changes in the vegetation zone due to an increase in mean annual temperatures	High
Changes in species composition	Changes in the growth rate and spread of trees	High
Animal area	Faster changes in animal areal due to changes in microclimatic conditions	High
Pollution of the atmosphere	Stress conditions due to air pollution	Medium high
Forest pests	Stress conditions weaken the variability of forest stands	High
Small forest rodents	Explosion of populations in warmer periods	High
Invasive organisms	Stress conditions provide faster and more successful expansion	Medium high
Weather extremes	Damage to forest stands	High
Ice breaking, overturning of ice and snow	Damage to forest stands caused by snow and ice	High

2.2.2. Non-forest stands and anthropogenically modified habitats

An important part of the Park's biodiversity is supported on non-forest surfaces with a large number of plant, animal and fungal species, and are significantly compromised by the end of traditional use and successive transformation.

Grassland habitats. These habitats are dependent on regular maintenance, but due to the abandonment of regular mowing and grazing absence, they slowly become infected with non-grassland vegetation. Therefore, the impact of climate change can indirectly affect these surfaces in a way that their traditional use is abandoned. This would gradually change their vegetation cover through the process of succession to the forest cover, representing a significant loss of biodiversity in the Park area. Degree of risk: medium high.

Fields, orchards, vineyards. By increasing time constraints, larger losses are anticipated, which could lead to a decision to abandon further use of agricultural land, pressure in the direction of using additional amount of water for irrigation and the use of higher amounts of agrochemicals and biocides to increase yields or obstruct the pests. Degree of risk: medium high.

Plots. More recently, there is a significant change in architectural design and use of plots at the Park’s area. House plots are regulated in accordance with the recreational functions, replacing the farm buildings and the smaller agricultural areas that were typical for the agricultural population. More intensive horticultural arrangements using crops that are not adapted to this area increase the need for irrigation and agrochemicals (biocides). The need for water is most pronounced during the summer months, which will increase pressure on water use. Reducing the herbal cover with deep roots changes the stability of the soil, which becomes more exposed to erosion. In the Spatial Plan of NPM, the spread of settlements is limited and they occupy a very small percentage of the Park. Degree of risk: low.

Table 2: The types and levels of risk for non-forest stands

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Grassland habitats	Abandonment of regular mowing	Medium high
Fields, orchards, vineyards	Pressure on water due to irrigation	Medium high
Plots	New stands in horticultural design and additional water needs	Low

2.2.3. Aquatic habitats (springs, streams, ponds, puddles)

The Medvednica springs are divided into permanent and occasional and their abundance depends on hydrometeorological conditions. Springs also supply streams, ponds and some puddles. In addition to streams, there are emerging streams that in the relief form rainwater and are only occasionally hydrologically active. Smaller ponds are usually formed in different depressions that temporarily retain water and are subject to large variations. The Medvednica aquatic habitats are small in size, but represent a significant habitat especially for amphibians. The impact of climate change on aquatic habitats can be manifested by: the reduction of medium annual flow, the occurrence of extremely low water levels and the flow during the more pronounced dry periods, the occurrence of extreme torrent flows, the rise of medium annual temperatures and extremely high water temperatures of small lenses units.

Springs, besides being important for overground organisms, are also important habitats for a unique rejuvenated fauna. Among them, the fauna of hypothyroidists and thermal springs are particularly prominent. The fauna of Mediterranean aquatic habitats is represented by a large number of invertebrates, amphibians and a small variety of fish that are mostly associated with ponds and streams

with constant flow. Important species of aquatic habitats are birds (e.g. blackbird) and submerged and coastal vegetation. The fauna of amphibians presents a special value of the Park, and it is also the most endangered due to the hydrological aspects of climate change that significantly alter the dynamics of slow water bodies that are crucial for the life cycle of these organisms. Torrent flows are a significant threat to fish. Extreme air temperatures, besides boosting evaporation, increase the water temperature, which has a significant negative effect on the metabolism of aquatic fauna. Increasing the mean annual temperatures and temperature extremes will negatively affect the flow of benthos.

Particularly significant pressure is the drainage of water for water supply. In the area of Medvednica, there is a rapid surface drainage of water and the abundance of springs depends on the precipitation. During significant dry periods, multiple negative impact on surface and hypo-existent stream habitats, which are supplied by sources, used for water suppression is expected. This pressure will especially increase if water exploitation is increased on existing watercourses and if new waterworks are built. Negative watering will not only affect aquatic, but also land habitats. Reducing groundwater levels increases the drought of habitats, which can have a negative impact on forest habitats where deep root system plants are most represented. Level of risk: high.

Table 3: Types and levels of risk for aquatic habitats

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Water pumping	Increased water exploitation, lower annual mean flow, lower groundwater levels	High

2.2.4. Surface and underground karst habitats

Due to extreme hydrological and meteorological conditions, surface karst habitats may be subject to additional drying, which may adversely affect the vegetation cover and the accompanying fauna. The underground karst habitats are characterized by hydrological extremes that occur due to the rapid leaching of the canal. Water is the main medium in which the nutrients penetrate into the underground; therefore, the underground organisms are consequently linked to hydrological changes. Reducing flow, extreme flow rates and uneven bursts of rainfall can disrupt the natural hydrological cycle in karst subterranean habitats. Extending the dry season may lead to an extension of the starvation period in underground organisms and to additional pressure on their caving schedules due to drought habitat. Torrent surface flows can affect the additional yield of sediment in the underground, which can negatively affect the underground fauna. Torrent currents within the caves can increased the drift of organisms (due to water flow). Level of risk: high.

Table 4: Types and levels of risk for karst habitats

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Disrupted hydrological cycle	Reduced nutrient yield in the underground, longer lasting and stronger hydrological extremes (droughts, torrent flows)	High

2.3. Soil

Erosion of the soil and landslides. The composition and soil properties of Medvednica are determined by geological surface and climate. The stability of the soil layers is affected by the slope of the terrain, the anthropogenic modifications such as the construction of roads, lanes, infrastructural constructions, and a particularly important factor determining the stability of the soil is the forest cover, one of the most important stabilizers. In addition to the surface erosion, there are also landslides present on Medvednica. Of the total area of the Park, 29.37% is affected by some form of process that leads to the instability of the soil layers. Climate change will affect the soil through hydrological and meteorological extremes and, to a lesser extent, possible fire consequences. Extremely high flows have the effect of creating torrent flows that significantly erode the area they are flowing. Large amounts of rainfall act so as to increase

slope instability, increasing the risk of landslide activation. However, the most pronounced adverse effects might have an impact on forest stands. In the case of extreme storms that cause significant damage to forest vegetation in the form of tree shrubs, a significantly more intense negative impact on soil stability is expected. Level of risk: high.

Table 6: Types and levels of soil erosion risk

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Erosion of the soil and landslides	Instability of the soil due to the abundant rainfall	High

2.4. Hydrology

Medvednica is extremely rich in streams and springs thanks to the impermeable or poorly permeable geological base (e.g. slates). However, in the south western part of Medvednica, where limestones and dolomites prevail, surface runoff is very scarce. The drainage is mostly very rapid as a result of the geological surface and the slope of the terrain. The hydrological condition of Medvednica represents a significant element of this area, which greatly affects biodiversity, but also all other elements of the Park.

Hydrotechnical procedures. In the Park there are 29 retention

and one reservoir whose function is the protection against the harmful effects of water. According to the NPM Spatial Plan, construction of other facilities of the same purpose is possible. The construction of hydraulic engineering works on Medvednica started very early and the methods used today were improved, mainly in such a way as to pose a minor threat to the preservation of habitats and biodiversity. Since all hydraulic engineering works are built on the basis of specific dimensioning of water barriers, there is possible damage to existing hydrotechnical procedures and their failure to fulfil their basic task (protection) in the event of extreme hydrological conditions. Level of risk: high.

Water supply. Part of the sources at Medvednica are used for water supply of settlements located in or near the Park or those that are partly included in the urban water supply system. The bulk of these sources depends primarily on the precipitation intensity. Because of its geological and geomorphological material, the Medvednica area can be described as a gradient, characterized by rapid water runoff. The impact of climate change can be reflected in reducing water availability and reducing its quality. During dry periods, a significant drop in water flow is expected. It should be borne in mind that the use of water for water supply must be balanced with the maintenance of environmentally acceptable flows (the so-called biological minimum). Due to extremely low flow rates during dry periods, it is possible that

the use of water from individual sources will be completely disrupted until water reserves are recovered. During the abundant precipitation periods, the water is often intensely blurred of water that presents a problem in water supply. Degree of risk: medium high.

Table 7: Types and levels of risk related to hydrology

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Hydrotechnical procedures	Possible damage to the existing hydrotechnical procedures	High
Water supply	Blurring or decreasing the availability of water	Medium high

2.5. Climate

There is no systematic research that would point to the intensity of the climate change trend in the Nature Park Medvednica. As an important climatic feature of this area, it is important to distinguish the natural heterogeneity of its space due to height differences, exposures, slopes relief, etc., but its significant modification effect to urban areas of Zagreb that act as a warm island but also an aerosol donor should not be forgotten.

Temperature. The influence of climate change on

temperature will have the following directions: increasing the mean annual temperatures and increasing the frequency of occurrence and the value of extreme summer temperatures. Level of risk: high.

Precipitation and wind. The impact of climate change on rainfall and wind will be manifested through an uneven distribution of rainfall, the occurrence of extremely abundant short-term heavy rainfall and extremely strong storm winds. Level of risk: high.

Snow cover. Global climate change projections suggest a reduction in the number of days with snow cover, reduced snowfall and snow cover thickness. Reducing the snow cover also decreases albedo, which significantly increases the temperature and creates a positive feedback. The absence or insufficient quantity of snowfall will increase the pressure on the ski resort impact on the site by increasing the need for different interventions (artificial snow production, using various chemicals required to preserve snow cover). Degree of risk: medium high.

Fires. The incidence of fires and their spread in continental Croatia, as well as in the Nature Park Medvednica, is not so pronounced, as is the case in the coastal area due to the specific climatic and vegetation characteristics. However, existing risks will arise in periods of intense drought and high

temperature periods. Degree of risk: low.

Table 8: Types and levels of risks related to climate

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Temperature	Increase in mean summer temperatures	High
Precipitation and wind	An uneven distribution of precipitation and extremes	High
Snow cover	Reduction of the number of days with a snow cover	Medium high
Fires	Not expressed in forest stands in continental Croatia	Low

2.6. Risk and vulnerability assessment for other constituents

Economic activities in the area of Nature Park Medvednica according to the Nature Protection Act (OG 80/13) are limited to those activities, which do not endanger the preservation of the value of this area.

Tourism in Nature Park Medvednica started to develop in the second half of the 19th century with a change of way of life (the expansion of Zagreb, industrialization). The

infrastructure for visitors such as hiking trails, mountain lodges, shelters, roads and so on begun to develop. Today, Nature Park Medvednica is located in a million population environment (the City of Zagreb, the County of Zagreb, Krapina-Zagorje County), representing a quarter of the total population of Croatia.

The Park has established a visitor system with a wide range of different contents and services: seven educational trails from which the “Bliznec Forest Trail” is adapted to people with disabilities. Information centres were set up at the main entrances to the Park, of which the Info Centre on Bliznec is in a tourist function. Three of the biggest tourist attractions are Veternica Cave, Zrinski Mine and Medvedgrad, which became the most visited site in Medvednica. In the future, it is foreseen that Medvedgrad will become a modern Centre for Visitors of the Nature Park Medvednica. Numerous other sites with emphasized natural and cultural value have been constructed, interpreted, marked and placed in the offer of the Nature Park Medvednica. In the network of different trails, besides the educational and hiking trails (70), the Marian Pilgrimage Path is a novelty, as well as since 2013 nine new bicycle paths (8 roundabouts and one ridge trail which is 150 km long). There are two hotels and 15 catering facilities (mountain lodges), a ski resort, several belvederes, etc. in the Park.

It could be concluded that the facilities and services for visitors are satisfactory in number and variety, ranging from mountain huts, ski resorts, belvederes, the cable car, which is an important object in the visiting system, medieval towns, Veternica Cave and Zrinski Mine, as well as many other cultural and natural sights that are included in the visiting system. However, it is necessary to raise their quality level (many objects need reconstruction).

Medvedgrad tourist facilities, Zrinski Mine and Veternica Cave are used as part of the activities of the Public Institution Nature Park Medvednica, and various cultural events such as concerts, film screenings, medieval festivals and others are held periodically.

Climate change will be reflected on these activities by modifying the Park's dynamics of visiting the Park (moving the so-called "peak" visits to early spring and late autumn months), then the aggravating circumstances in the implementation of events and educational programs (extra-classroom activities) due to the sudden occurrence of extreme climatic events (e.g. storms). It is also possible to increase the cost of insurance for employees of the PINPM, as well as visitors through the price of tickets, as well as manifestations in general.

Furthermore, the impact of climate change on the snow cover

will lead to a reduction in the duration and quality of the ski slope, and investments in its operation and maintenance will be more expensive. Degree of risk: medium high.

2.6.1. Visitors

The change in the dynamics of visits to the Park will manifest itself due to reduced safety of visitors during extreme weather events such as storms. This impact will not be limited to the short periods in which these events are present but will have a long-term impact through negative advertising.

The degradation of forest components that are a fundamental phenomenon of the Park due to storms, droughts, debris, forest pests and phytopathogens can affect a positive image of the Park and cause negative publicity. Increased populations of small forest rodents that are transmitters of hemorrhagic fever virus can also contribute to creating a negative image of the Park. Degree of risk: medium high.

2.6.2. Infrastructure

There is a large number of different stakeholders who manage the total infrastructure for visitors to the Nature Park Medvednica. Many objects are in long-standing property law disputes, resulting in a poor infrastructure situation.

This especially relates to the facilities such as Villa Rebar, Brestovac, Prekratić House, the Railway House, the Trade Unions House. The condition of mountain lodges, ski resorts, traffic infrastructure and other communal infrastructure is also not in line with the quality standard required to improve the tourist function of the Park, and in particular for the environmental objectives. For the purpose of analysing the spatial layout of the visitor infrastructure, it was established that the visitor infrastructure occupies about 180 hectares of the Park's area (1%), but it is not evenly distributed. Areas under heavy load in the peak zone are the central part and those near the Sljeme road.

Unfortunately, the recent economic situation does not contribute to solving the problem of Medvednica, which is why overall stagnation of development has occurred. It is necessary to insist in the planning documents that at the time of renovation or complete reconstruction the principles of high-energy efficiency are respected.

The condition of the entire infrastructure in the Park is getting worse because no significant investments have been made recently. Over the past few years there were investments in two smaller catering facilities in the peak zone. The Medvedgrad project has applied to EU structural funds (measure 6c2), whose implementation should have been completed by the end of 2019, in the scope of which

two of the three major landslides have been remediated stretching from Medvedgrad - Kraljičin Zdenac - Šestinski Lagvić). Investments were also made to improve the tourist function of the Veternica Cave and the Info centre Bliznec. For the renovation of the third large landslide, documentation is being prepared and works are scheduled for September 2017.

In general, the infrastructure is in poor condition and requires the financial investments of all stakeholders, making it vulnerable to climate change, particularly in the event of extreme events such as storms (winds, landslides, large water). Level of risk: high.

2.6.3. Agriculture

On one hand, in the area of Urban Agglomeration Zagreb (three counties where NPM is administratively located), more than 15,000 family farms with a tendency of growth have been registered, since the production of healthy food and high-quality domestic products is a priority in today's agricultural production. On the other hand, the population of the Park engaged in farming represent an important component of biodiversity conservation since the agricultural areas support a part of the non-forest species (as described in the previous chapters). The consequences of climate change can exacerbate pressure on the population engaged

in agriculture in the Park in the direction of withdrawing from further agricultural production or reducing its current scope due to the disadvantages that this activity is facing in Croatia. Grasslands that support a large number of strictly protected species are of particularly great value. Degree of risk: medium high.

2.6.4. Population

The territorial aspect has a very positive impact on the development of the Park from different aspects (cultural, recreational, educational, tourist and other) and thus a strong regional influence on a wide area since the Nature Park Medvednica is administratively located in three counties, which together make 4,930 km² or 9 % of the territory of the Republic of Croatia:

- Zagreb County (3,060 km²),
- Krapina-Zagorje County (1.229 km²) and
- City of Zagreb (641 km²).

The average population density of these three counties, for which the development of the Zagreb Agglomeration Development Strategy has been initiated, is almost 373 inhabitants per km², while in case of the exclusion of Zagreb average population density is reduced by almost three times and is 130 inhabitants per km². The total area of Nature Park

consists of 28 settlements or parts of settlements.

Demographic aspect. According to the census of 2011, there were 4,284,889 inhabitants in the Republic of Croatia, of which 2,218,554 were women and 2,066,335 were men. Since 2009, the Republic of Croatia has recorded a negative migration balance. The territory of the Republic of Croatia is not uniformly inhabited. The average population density in 2011 was 75.7 inhabitants / km² with a range of 9.5 (Lika-Senj County) to 1.232.5 inhabitants / km² (City of Zagreb).

The average age of the population in 2011 was 41.7 years (43.4 years for women and 39.9 years for men). Envisaged life expectancy in 2011 was 79.9 years for women and 73.8 for men. The birth rate was 9.4‰ and the mortality rate was 11.6‰.

According to the 2011 census, the number of inhabitants was:

- 317,606 in the County of Zagreb,
- 132 892 in Krapina-Zagorje County and
- 790 017 in the City of Zagreb.

Around 1.24 million inhabitants live in the region, which is slightly less than 30% of the population of the Republic of Croatia or just over a quarter of the total population of the Republic of Croatia.

Population and settlements in NPM - Few European capitals have in their immediate vicinity a nature park as it has Zagreb. It represents an immeasurable value for the inhabitants and the surrounding areas as is evident from historical events.

The Bistrica area of the Park is predominantly an agricultural area with orchards. It is located in the extreme western part of the Medvednica foothills that stretches along the Stubička cesta, from Podsusedski Dolj to Stubičke Toplice. The largest settlements are Gornja Bistra and Jablanovac, and the population is increasingly focused on Zagreb.

The Stubica area of the Park is located on a steep part of Medvednica and therefore has the difficult natural conditions for the development of settlements, except in the lowlands. The population is concentrated in Donja Stubica and Stubičke Toplice. The settlements of the Gornja Stubica Municipality have largely maintained the traditional character of the village.

The Zagreb part of the Park is almost completely uninhabited, except for a few residents in Gornja Dubrava (Jakopovići).

The Sesvete foothills is located in the southeastern part of the Park and encompasses the whole village of Planina Gornja and the northern uninhabited parts of Kašina and Planina Donja. It is mostly rural, less urbanized area.

2.6.5. Protection and rescue

In the City of Zagreb there is an administrative body that carries out tasks related to the preparation and participation in the protection and rescue from accidents, major disasters and catastrophes. There is also the body that organizes the preparation and participation of operational forces for preventive protection and rescue, response to accidents, disaster and the removal of their possible causes and consequences.

The Croatian Mountain Rescue Service operates in the area of NP Medvednica. Significant number of emergency interventions were also performed by the employees of the Institute for Emergency Medicine and the members of the Public Fire Department (JVP) and voluntary fire brigade companies (DVDs).

In other areas of Nature Park Medvednica within the Urban Agglomeration Zagreb, under the jurisdiction of Zagreb County and Krapina-Zagorje County, Protection and Rescue Departments were established and required implementing documents were established.

With regard to the position of the Park - within the three counties with a high population density - as well as the high level of attendance throughout the year, climatic changes

will pose a risk to both the local population and visitors of the Park, the most obvious consequence of which will be the extreme events of rising temperatures and the appearance of storms. Furthermore, there is a trend of rising elderly residents of the surrounding area who, for health reasons, are increasingly visiting the Medvednica forests during the extremely hot summer days.

Table 5: Types and levels of other risks

RISK AREA	RISK DESCRIPTION	RISK LEVEL
Tourist activity	Modification of the dynamics of the visits to NP Medvednica due to climate change	Medium high
Visitors	Biodiversity changes (e.g., rodent growth and mouse fever increase)	Medium high
Infrastructure	Convenience and low energy efficiency of facilities	High
Agriculture	Discontinuation of agricultural activity in the Park due to climate change	Medium high
Population	Impact on the development of the Park	Low
Protection and rescue	Increased activity due to ecological disasters	Medium high



3. Identification and analysis of options for adaptation

Adaptation options should allow the reduction of adverse effects to an acceptable level. They may include capacity building for adaptation (including information exchange) and concrete measures (technical solutions, security instruments). When the main problems are identified, adjustment options are being developed including the main actors. After identification, an analysis of options is performed, including ranking and selection of priorities, along with the description of the criteria used to define the priorities. This can include efficiency in reducing vulnerability (increased resistance), cost effectiveness, etc.

3.1. The basic goals of adaptation in the Nature Park Medvednica

The basic goals of adaptation to climate change in the Nature Park Medvednica are to reduce the negative impacts of climate change to an acceptable level and to disseminate general knowledge on climate change issues so that acquired experiences and knowledge and examples of good practice can be transferred to other sectors as well.

Based on the thematic priorities, the adaptation goals will be defined, and based on them an action plan will be defined with activities to be undertaken in response to the risks. It will determine which planning documents are relevant to the specific activities, deadlines and responsibilities for their implementation.

3.2. Thematic priorities

Based on the available analyses, the existing information and the state of the Park it is possible to define a number of thematic priorities important to the creation and continuous improvement of adaptation to climate change:

1. Scientific and professional research
2. Education

3. Planning and Adaptive Management
4. Lobbying, creating and strengthening partnerships.

3.2.1. Scientific and professional research

Scientific and professional research is the basis of all activities related to climate change adaptation since they can give us an insight into the current situation and projections of the future state of all environmental and socio-economic aspects as well as many other implications. Unfortunately, most studies require long-term monitoring and often substantial financial investment. Therefore, the dynamics of research and their scope are limited by the financial resources available to the PINPM. In addition to research funded by the PINPM, there is a great potential for scientific and professional research carried out by various scientific institutions, professional organizations and independent experts, which can be funded from other sources. There are also surveys funded by public companies that manage certain components within the Park (e.g. Croatian Roads, Croatian Forests, etc.). Relevant scientific and expert data are necessary to assess vulnerability of species and habitats with a view to improving climate change mitigation measures.

The drafting of climate change adjustment measures must be preliminarily made despite a significant shortage of target data. Knowledge gaps and the uncertainty factor of data can be compensated by using available scientific data on

directions and impacts of climate change in similar conditions in wider regional areas.

In order to be able to keep up to date with new scientific findings and recommendations, it is crucial to provide flexibility in making and implementing new recommendations aimed at improving climate change adaptation by using internationally accepted projection results as well as possible adaptation measures.

Considering the analyses carried out in this project, the following priority scientific research has been identified that will help to increase knowledge about the current and future impacts of climate change:

- a. meteorological research
- b. hydrological research
- c. biological research
 - i. forests
 - ii. aquatic habitats
 - iii. grassland habitats
 - iv. endangered species and habitat types
 - v. target species and habitat types of the ecological network of the Republic of Croatia
 - vi. exploration of underground habitats (caves and pits) –
- g. other applied research

3.2.2. Education

Quality and interdisciplinary education of all employees of the Park on climate change is the first and most important step that will help them distinguish the impacts attributable to climate change and which are the most appropriate measures for their mitigation. Science-based education of employees is also significant because they will be the main providers of information to the Forum of stakeholders and attendees of education, as well as to expert guidance in the Park area as well as beyond. As the projection models are constantly improving and new adjustment measures are being created, the need for ongoing education continues to be a challenge. Because of the occasional employee fluctuation, it is necessary to educate all new workers so that they can continue working on the same platform for adapting to climate change and spreading scientifically based information.

The NPM stakeholder forum is an excellent example of interest groups for whom thematic and targeted education related to climate change can be made. Due to the continuous work of the Forum, it is also possible to specifically measure the information and monitor the progress of implemented measures. The PINPM can be an information point where members of the Forum can look for help regarding the implementation of measures.

The Park is an extremely important educational supplier, which also presents an extension of the educational system in the Republic of Croatia. In addition to school children, the education includes a variety of groups of visitors who are organized or self-adventured in the Park and participate in various events, those who visit some of the Park's localities or participate in educational programs, and the topic of climate change can be incorporated into different methods of education and interpretation.

3.2.3. Planning and Adaptive Management

Long-term and short-term planning are the main principles of work of the PINPM, based on which the financial resources and activities of employees are reallocated in accordance with the established guidelines in the specified time period. Planning presents a good method of operation, especially when the activities are specified within the set execution deadlines and responsible persons are named, as well as when it is followed by the evaluation of the realization. However, long-term planning has a problem since it is difficult to implement new measures after the deadline for the drafting of planning documents. This is particularly related to long-term planning which significantly limits the possible changes. Therefore, it is necessary to introduce so called flexible planning, or adaptive management that enables the

rapid implementation of new measures to adapt to climate change in all planning processes and their efficient and timely realization. It is particularly important to introduce co-operation between different stakeholders at the planning stage and to ensure interdisciplinarity in applied research, as well as in the design and implementation of climate change adjustment measures.

3.2.4. Lobbying, creating and strengthening partnerships

Nature Park Medvednica has been recognized as an important public institution that is the bearer of new ideas and experiences in the field of nature conservation, as well as general public awareness of the importance of environmental protection, contemporary environmental problems and challenges, including climate change. Precisely in the context of climate change, the PINPM can be profiled as a significant institution that will, by presenting its very impressive examples of damage caused by climate change (e.g. stormy weather), have a significant and influential role in the lobbying process for timely implementation of adjustment measures.

In order to achieve the synergy effect of implementing specific measures and spreading good practice examples to the wider area, it is necessary to create partnerships and

invest in the further development of existing partnerships. Networking is also an excellent information exchange tool that can serve to improve customization methods as well as bridging individual weaknesses.

Key identified activities contributing to the achievement of the set goals in combating climate change are as follows:

ACTION PLAN FOR THE PERIOD 2017-2019

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
A. Protection and conservation of natural resources							
1	Analysis of all existing data on the impact of climate change in the area of NPM (e.g. various publications, damage records in the Park etc.)	Insufficient availability of existing data on NPM	Annual plan	2018	PINPM Expert service	PINPM Expert service Ranger service External associates Volunteers	List of publications and their easy availability Analysis of existing data
2	Collection and processing of meteorological, hydrological and other data from relevant stations and drafting of climate trends for NPM	Not using existing data that would help to better understand climate change	Annual plan	2018 - 2020	PINPM Expert service	External associates PINPM Expert service	Developed projections of climate change based on meteorological and hydrological trends
	Ensuring the implementation of applied research and monitoring of changing environmental conditions with the aim of assessing vulnerability of habitats and species	Insufficient applied environmental research	NPM Management Plan	2018, and thereafter continuously	PINPM Expert service Ranger service	PINPM Expert service Ranger service External associates Volunteers	Number of research Number of species covered, habitat types and other environmental constituents
	Analysis and risk assessment in NPM due to the increased incidence of extreme events	Lack of flexibility	NPM Management Plan	2017/2018	PINPM Expert service	PINPM Expert service Technical service Ranger service External associates	Targeted risk assessment developed of the frequency of extreme events

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Creating a space-time chart of increased risk of climate change impacts and its regular updating	Insufficient knowledge of climate change most intense points Inability to direct activities to the most important zones	Management Plan Annual plan	2019, and thereafter every three years	PINPM Expert service	PINPM Expert service Ranger service Technical service External associates	Created map Updated map depending on new data
	Drafting climate change adaptation measures in the scope of which cost-benefit analysis of the result of climate change impacts in relation to investments in adaptation will be made	Inadequate measures due to lack of data and poor estimates	Management Plan	Every three years	PINPM Expert service Management of the PINPM	PINPM Expert service Ranger service External associates Management of the PINPM	Adaptation measures made Positive rating of cost-benefit analysis for the mentioned measures
	Revision of climate change adjustment measures	Non-adaptability	Annual plan	Every year	PINPM Expert service Management of the PINPM	PINPM Expert service Management of the PINPM External associates	Realized revision of climate change adjustment measures
	Implementation of the topic of climate change impacts and adaptations to climate change in the NPM Spatial Plan	Insufficient affirmation of climate change topics	NPM Spatial Plan	Whenever any change or adoption of a new spatial plan occurs	PINPM Expert service Management of the PINPM	PINPM Expert service Management of the PINPM	Satisfactory implemented measures in the spatial plan

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
B. Protection and preservation of cultural heritage							
	An analysis of the impacts of climate change on cultural heritage and the development of adjustment measures	Ignorance of the impact of the climate change on cultural heritage Lack of targeted adjustment measures for this sector	Annual plan	Every year	PINPM Expert service Service for Promotional Activities Management of the PINPM	PINPM Expert service Service for Promotional Activities External associates Management of the PINPM	Developed impact analysis Developed adaptation measures
C. Collaboration with the local community							
	Among the members of the Forum of Shareholders, select and set up a Professional Advisory Council to assist in improving the adjustment measures in the NPM area	Insufficient capacity of the PINPM Inability to engage professional consultants due to financial constraints Inability to devise better quality adjustment or non-recognition of the inefficiency of existing adjustment measures	Management Plan Annual plan	2018	PINPM Expert service Management of the PINPM	PINPM Expert service Management of the PINPM	Established expert council The representation of members from different professional and scientific fields
	Informing stakeholders groups of the Forum of stakeholders NPM on climate change scenarios and responses (e.g. Interest group related to forest, non-forest habitats, infrastructure etc.).	Ignorance of the topic of climate change Not knowing the attitudes of stakeholders Unwillingness to implement adjustment measures	Annual plan	Continuously	PINPM Expert service	PINPM Expert service Ranger service Technical service Management of the PINPM External associates Volunteers	A minimum one-year meeting with stakeholders held with topics of climate change

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Strengthening the Stakeholders Forum and building partnerships to respond to the consequences of climate change	Inability to unite stakeholders in order to achieve synergistic effect of joint action	Annual plan	Continuously	PINPM Expert service	PINPM Expert service Ranger service Technical service Management of the PINPM External associates Volunteers	A minimum one-year meeting is held to consider ways of networking and adaptiveness and the benefits of the same
D. Education and interpretation							
	Education of members of the NPM Forum on Climate Change	Ignorance of the topic of climate change	Management Plan	Continuously	Service for Promotional Activities PINPM Expert service	Service for Promotional Activities Ranger service PINPM Expert service External associates PINPM Volunteers	A special program on climate change developed Continuous education
	Visitor education through the implementation of climate change themes into existing educational and interpretation programs	Ignorance of the topic of climate change	Annual plan	Continuously	Service for Promotional Activities PINPM Expert service	Service for Promotional Activities PINPM Expert service External associates Volunteers	Implemented themes of climate change into existing programs

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Lobbying on the importance of implementing adaptation measures in areas beyond NPM	Ignorance of the topic of climate change	Management Plan Annual plan	Continuously	Service for Promotional Activities PINPM Expert service	Service for Promotional Activities PINPM Expert service Management of the PINPM External associates Volunteers	The number of held meetings, press releases and similar events mentioning adaptation to climate change
E. Visiting and promotion							
	Analyse the impact of climate change on the dynamics of visits and develop adaptation measures related to visiting and promotion	Not knowing the climate change real influence on visiting Inability to make mitigation measures	Management Plan Annual plan	2019	PINPM Expert service Service for Promotional Activities Technical service Management of the PINPM	Service for Promotional Activities PINPM Expert service External associates Management of the PINPM Volunteers	Developed analysis and adjustment and mitigation measures
	Issuance of promotional materials in digital and / or printed form on climate change issues in NPM adjustment measures in order to use the NPM as an “example of effective climate change adaptation practices”	Inability to spread reliable information on climate change	Annual plan	2020	PINPM Expert service Service for Promotional Activities Management of the PINPM	Service for Promotional Activities PINPM Expert service External associates	Developed promotional materials Their availability to visitors and other interested groups

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
F. Fire protection							
	Adapt action plans for crisis situations with local governments and self-government units	Too many plans Their inconsistency Ineffective implementation due to insufficient information exchange	Annual plan	2019 and thereafter as needed	PINPM Expert service Management of the PINPM Technical service	PINPM Expert service Management of the PINPM Technical service	Harmonized plans Revised Plans
G. Development of institution's capacity							
	Preliminary training of PINPM staff on climate change and continuous training	Ignorance of the topic of climate change	Management Plan	2017 - 2020	Management of the PINPM	Management of the PINPM External associates	Fundamental training conducted, participation in seminars, lectures, education
	Introducing climate change themes into the strategic planning documents of the Park	Impossibility of rapid and effective implementation of climate change adaptation measures due to formal obstacles	Spatial Plan Management Plan Sustainable Tourism Strategy	2018 - 2020	Management of the PINPM	Management of the PINPM PINPM Expert service	The topics of climate change introduced into mentioned documents
	Creating volunteer programs that will be thematically related to climate change issues (collecting literary and field data and smaller analysis) and their revision	Insufficient capacity of the PINPM	Management Plan	2017, revision as needed	PINPM Expert service Management of the PINPM	PINPM Expert service	Developed and implemented volunteer programs Revised Plans

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Education of volunteers who will volunteer on programs related to climate change issues	Ignorance and lack of understanding of the topic of climate change	Management Plan	Continuously	PINPM Expert service Management of the PINPM	PINPM Expert service External associates Previously educated Volunteers	Educated volunteers
	Realization of programs that will be based on volunteer work	Insufficient capacity of the PINPM Inability to collect relevant data	Management Plan	2018, 2019, 2020	PINPM Expert service Management of the PINPM	PINPM Expert service Service for Promotional Activities External associates	Results of realization

H. Sustainable Tourism Strategy

	Implement measures related to adaptation to climate change in the Sustainable Tourism Strategy	Inadequate share of climate change themes in this document	Sustainable Tourism Strategy	2019	Management of the PINPM	Management of the PINPM PINPM Expert service Service for Promotional Activities	Implemented measures
	Implementation of green principle in relation to transport, buildings, lighting and green infrastructure and renewal of the Certificate for Sustainable Tourism	Promotion of adaptation measures to climate change	Management Plan Sustainable Tourism Strategy	Continuously	Management of the PINPM	Management of the PINPM PINPM Expert service Service for Promotional Activities	Implemented Green Principles Renewed Certificate for Sustainable Tourism

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