# Assessment of vulnerability and climate change risks for Sofia Municipality

## Analysis of the current situation by sectors

Sofia, December 2020

## Author's team

This report was developed by a team of DZZD ENEFECT-GROUP in accordance with the work plan for implementation of a public procurement from 2019 of Sofia Municipality (SO) with subject "Development of a plan for sustainable energy and climate for the period 2021 - 2030." The texts are in accordance with the comments of participants in the expert council of Sofia Municipality, created specifically to monitor the implementation of activities under the contract. The individual sections of the report have been developed by the following authors, arranged in the order of the content of the report as per the the sections in the preparation of which they participated:

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## List of abbreviations

| Abbreviation | Meaning |
|---|---|
| CCA | Climate change adaptation |
| RES | Renewable energy sources |
| GD | General Directorate |
| GIS | Geographic Information System |
| GSMCE | Global Covenant of Mayors on Climate and Energy |
| IPCC | Intergovernmental Panel on Climate Change (IPCC) |
| NSI | National Statistical Institute |
| UN | United Nations |
| SECAP | Sustainable Energy and Climate Action Plan |
| SEAP | Sustainable Energy Action Plan |
| SUMP | Sustainable urban mobility plan |
| WHO | World Health Organization |
| SM | Sofia Municipality |
| $CO_2$ | Carbon dioxide |
| ETIS | European system of indicators for sustainable tourism management in destinations |
| FSC | Forest Stewardship Council |
| GPS | Global positioning system |
| IPCC | Intergovernmental Panel on Climate Change |
| RDF | Refuse-derived fuel |
| SWOT analysis | Analysis of strengths, weaknesses, opportunities and threats |
| UNEP | United Nations Environment Program |
| WMO | World Meteorological Organization |

## Specific terms used

| Term | Meaning |
|---|---|
| Adaptation capacity | The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.* |
| Impact | Effects on natural and human systems. The term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change* |
| Exposure | The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected. * |
| Climate hazard | The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.* |
| Vulnerability | Degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. ** |
| Sensitivity | Sensitivity is the degree to which a system will reposnd to a change in the climatic condition. E.g. exent of change in ecosystem composition, structure and functioning. *** |

** Source: IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.*
*https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf*

*** Source: Guidebook 'How to develop a Sustainable Energy and Climate Action Plan (SECAP)*

**** Source: http://www.inforse.org/europe/dieret/Climate/climate%20graphics/25.htm*

# 1. Introduction

This report was developed in accordance with the work plan for implementation of the public procurement of 2019 of Sofia Municipality (SM) with subject *"Development of a plan for sustainable energy and climate for the period 2021 - 2030."* The need to prepare an Action Plan for Sustainable Energy and Climate (SEECP) stems from the commitment to the global efforts to mitigate climate change expressed by the SM through its accession to the Global Covenant of Mayors for Climate and Energy (GCMCE) for the period 2021-2030. to the international initiative is formalized by Decision № 755 / 08.11.2018 of the Sofia Municipal Council and is a natural continuation of the participation of the Municipality in the Covenant of Mayors and the implementation of the *Action Plan for Sustainable Energy Development (SECAP)* of Sofia Municipality 2012 – 2020.

The GCMCE rules stipulate that each municipality joining the initiative will prepare and implement its SECAP, which will describe the climate and energy policies that the municipality will follow, together with the measures and activities it will implement in order to "mitigate" the effects of climate change by reducing greenhouse gas emissions and "adapting" to the negative effects of climate change.

The main purpose of the development of this report is to analyze the climatic hazards for the territory of the municipality and assess the vulnerability and impact of these hazards in order to determine the main climatic risks for the municipality. In addition, it aims to define specific indicators for monitoring of the vulnerability and impact. Such an assessment for the territory of Sofia Municipality has not been performed so far and the results of the analyzes in this report will serve as a basis for the development of the SECAP of the Municipality in the part "adaptation" to climate change, and for determining the measures to be taken by the municipality by 2030 in the process.

According to the procurement documentation, the team involved in its implementation includes experts on the following topics: "Strategic Planning", "Climate – Reduction of Greenhouse Gases", "Energy, Energy Efficiency, RES and Biofuels", "Databases", "Transport","Waters","Forestry and Agriculture, Landscaping and Land Use", "Urban Planning", "Civil Protection, Disasters and Accidents","Environment and Biodiversity","Waste", "Tourism" and "Human health". The terms of reference for the public procurement require, as part of the work plan for the development of SECAP, to prepare an analysis of the current situation by sector, which should include a description of political, economic, social and technological factors affecting the development of the sector. In addition, the assignment requires a SWOT analysis to examine the following strategic links: how to use strengths so as not to miss available opportunities, how opportunities to help neutralize weaknesses, how the strengths are used to reduce threats, which weaknesses need to be removed to reduce threats. The vulnerabilities to climate hazards and climate risks identified in this report are a topic on which, as a next step, such a SWOT analysis will be prepared to help select appropriate measures and activities for adaptation to climate change.

This report contains a summary and four main sections. The first of them presents the methodology used by the authors regarding the assessment of the exposure of the territory of Sofia Municipality to climate hazards, the degree of vulnerability, and their impact in individual sectors and the identification of climate risks and monitoring indicators. Outside the terms of reference, a proposal has been developed to implement a "Single System" approach for the analysis of the entire socio-ecological system in order to ensure cross-sectoral integration, comparability of indicators, to draw conclusions about environmental "red lines" and existing development needs. This approach is

presented in the appendix. Geospatial analysis using the "Single System" approach allows systematization and simplification of the search for sustainable and climate-adapted urban solutions.

After the description of the used methodology, in a separate section of the report, a detailed analysis of the climate in Sofia Municipality, its parameters, factors for climate change and climate hazards is defined, together with an assessment of the exposure of the territory to these climate hazards. The exposure assessment was used to make assessments of the degree of vulnerability and the level of impact of climate hazards, carried out separately for each sector. The assessments are presented in the next section of the report, which also presents the sectoral analyzes, including an assessment of the factors for the development of the sectors, incl. political, economic, social, technological and environmental factors. The sectoral analyzes concern the sectors: "Water", "Forestry and Agriculture", "Urban Planning", "Civil Protection, Disasters and Accidents", "Environment and Biodiversity", "Waste", "Buildings", "Transport", “Tourism” and “Human Health”. For each sector, the analysis ends with a sectoral SWOT analysis. Vulnerability and impact of climate hazards have not been assessed for the Civil Protection sector alone. The reason for this is that this sector serves the other sectors and the vulnerability and impacts are manifested in the served sectors and not in the Civil Protection sector itself.

The last section of the report presents a summary analysis of the most highly rated vulnerabilities in each sector and a summary of all the highest climate risks identified. For each of them, the climatic hazard from which it originates, the sector affected and the expected impact are described. Vulnerability and impact monitoring indicators are summarized for all high climate risks.

For the analysis, data provided by the SM were used, which were specially collected for the implementation of the public procurement, according to a model for data collection prepared at an earlier stage. In addition, data from publicly available sources and own databases of the participating experts were used.

# 2. Methodological approach

## 2.1. Methodology for analyzing the vulnerability and impact of climate change and identifying climate risks

The rules of the Global Covenant of Mayors for Climate and Energy (GCMCE) include the requirement that Sustainable Energy and Climate Action Plans (SECAPs) and subsequent periodic reports on the implementation of the plans be summarized in a pre-defined mandatory form. Regarding the adaptation of the municipality to climate change, each municipality is expected to present assessments of adaptation capacity, climate hazards, vulnerability to these climate hazards and their impact in individual sectors. Based on these assessments, the municipality must plan and implement appropriate adaptation measures. In addition to the assessments, measurable indicators for the vulnerability and impact of climate change on the territory of Sofia Municipality must be presented, as well as for monitoring the progress of the municipality after the implementation of adaptation measures.

The analysis is based on several key definitions of the main indicators for assessments related to the adaptation of a particular ecosystem to climate change - ***climate hazard, exposure, sensitivity, vulnerability, impact and climate risk.*** These definitions are presented together in one place just before the introduction of the report. *The definitions used in the analysis are either specified by the Intergovernmental Panel on Climate Change (IPCC) or specified in the form to the SECAP Development Guide.*

By assessing each of the listed indicators and consistently monitoring the total effect of the combined action of certain indicators, the climate risks for Sofia Municipality are finally determined. Figure 1 shows a logical diagram of the process of climate risk assessment.

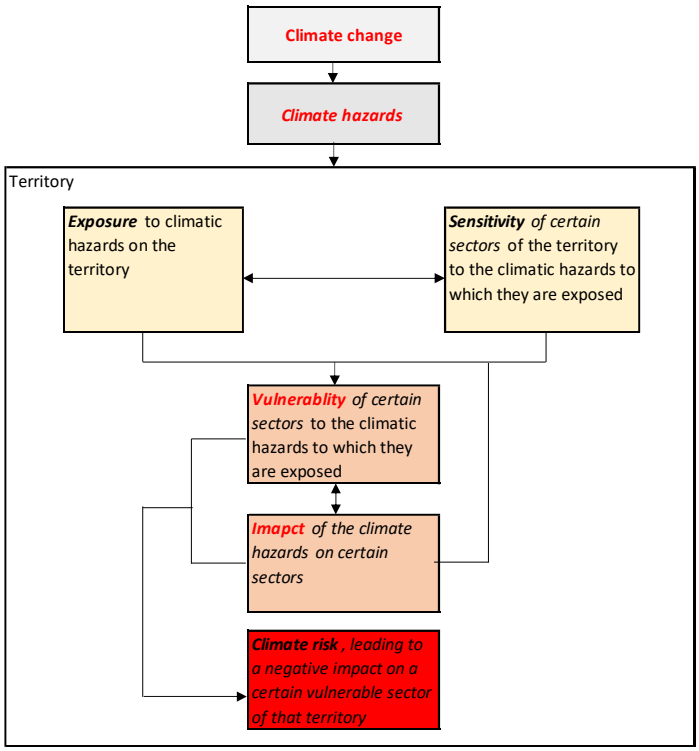


*Fig. 1. Logical diagram of the process of climate risk assessment*

### 2.1.1. Determination of adaptation capacity

According to the definition of the *Intergovernmental Panel on Climate Change (IPCC)*[1]

> ***adaptation capacity*** *is the combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.*

The assessment of the adaptation capacity is performed at the municipal level, and according to the requirement of GCMCA it should be based on filling in a self-assessment card by the municipal administration. In support of the self-assessment and in addition to this report, an analysis of the impact of 5 groups of factors (political, economic, social, technical and environmental factors) of the sectors identified by Sofia Municipality as sensitive to climate change is developed. The analysis in each sector is carried out through the prism of adaptation to climate change and covers the political, economic, social, technical and environmental factors to which each sector is exposed. As a result, a summary SWOT analysis was performed to support the assessment of Sofia Municipality for the adaptation capacity.

### 2.1.2. Identification of climate hazard

According to the definition of IPCC[2]:

> ***hazard*** *is the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.*

In order to determine the climatic hazards for the territory of Sofia Municipality, an analysis of a large volume of data on many climatic parameters was performed. The analysis and description of the identified climatic hazards are presented in the section "Climate in Sofia Municipality". For each climate hazard, the current level of hazard (exposure) is assessed on a three-point scale, as described below in the “exposure assessment” (point 3.2.3.1), as part of the municipality’s “vulnerability assessment” to climate change. In addition, according to the forecasts for changes in the analyzed climatic elements and phenomena, the expected change in the intensity and frequency of each of the climatic hazards is presented again on a three-point scale, as indicated in the form to the manual for preparation of SECAP - "increase", reduction "or" no change ". For each of the climate hazards, it is indicated in which period this change is expected - "current moment", "short-term", "medium-term" or "long-term" (Table 1). Separately, Section 4 provides definitions of the

[1] IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564. https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf

[2] Пак там

importance of climate categories and measurable indicators for monitoring the expected change associated with each of the climate hazards.

*Table 1. Duration of the periods in which changes in the considered climatic phenomena are expected*

| **Period** | **Duration** |
|---|---|
| Present | By 2023 |
| Short-term | By 2030 |
| Medium-term | By 2050 |
| Long-term | By 2100 |

### 2.1.3. Vulnerability assessment

According to the definition of the IPCC, vulnerability is the tendency or predisposition of the studied system to be adversely affected. The definition recorded in the form to the PDUE development manual states that:

> ***vulnerability*** *is the degree to which a system is vulnerable and unable to cope with the adverse effects of climate change, including climate change and extremes.*

According to the document *of the* European Commission's Directorate-General for Climate *Guidelines for Project Managers: Making vulnerable investments climate resilient* [3], the degree of vulnerability to climate change is defined as a function of two characteristics - exposure and sensitivity to climate hazards:

$$V = S \times E \qquad (1),$$

where: *V* is the vulnerability of the sector concerned to the specific climate hazard, *S* is the degree of sensitivity for the sector concerned and *E* is the exposure to the underlying climatic conditions / side effects.

Here is the place to introduce two more definitions to clarify the nature of the assessment. As defined in *IPCC*:

> ***the exposure*** *is the presence of people; subsistence; environmental services and resources; infrastructure; or economic, social or cultural values in places that could be adversely affected.*

A definition of sensitivity[4] has been proposed by UNEP, WMO and Cambridge press university and states that:

[3] European Commission Directorate-General Climate Action, Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient: https://climate-adapt.eea.europa.eu/metadata/guidances/non-paper-guidelines-for-project-managers-making-vulnerable-investments-climate-resilient/guidelines-for-project-managers.pdf

[4] http://www.inforse.org/europe/dieret/Climate/climate%20graphics/25.htm

***sensitivity*** *is the degree to which a system will reposnd to a change in the climatic condition. E.g. exent of change in ecosystem composition, structure and functioning.*

According to the formula presented above, before proceeding with a vulnerability assessment, an exposure and sensitivity assessment must first be performed, for which the following approach has been used:

#### *2.1.3.1. Exposure assessment*

In a multisectoral analysis at local level, such as the current one, it is difficult to say that individual sectors have a specific exposure to climate hazards. It is more correct to say that the whole municipality is exposed to the identified climatic dangers, and the individual sectors have different sensitivity, including the lack of such (i.e. zero sensitivity), to them. Therefore, the exposure to climate hazards is determined at the municipal level, in the section "Climate in Sofia Municipality" of the report and it is the same for all sectors.

A three-level color scale similar to that used to assess sensitivity and described below, which in turn is borrowed from the methodology "*Guidelines for Project Managers: Making vulnerable investments climate resilient*", is considered to assess exposure levels. The exposure assessment, as well as all other color scale assessments, have been further upgraded with numerical values, as a large number of sectors are covered and the summary at the municipal level needs to be able to rank the results that fall into the same color scale range (Table 2).

*Table 2. Degrees for estimating exposure to climate hazards*

| Exposition | Score in numbers | Definition |
|---|---|---|
| **High** | **3** | Objects affected by climate hazards are exposed to > 50% more hazards than their long-term average |
| **Moderate** | **2** | Objects affected by climate hazards are exposed to 25-50% more hazards than their average long-term |
| **Low** | **1** | Objects affected by climate hazards are exposed to <25% more hazards than their long-term average |

#### *2.1.3.2. Sensitivity assessment*

Each of the analyzed sectors is affected by different climatic hazards to different degrees, due to which there is a different sensitivity to them. Therefore, the sensitivity assessment was performed separately for each sector.

In the analysis of environmental factors, as part of the analysis related to determining the adaptation capacity of the municipality, experts in each sector determine the climatic hazards relevant to the sector from those identified for the municipality. These climate hazards, to which a sector is sensitive, are assessed on the scale described below, following the example of the methodology described in *the Guidelines for Project Managers: Making vulnerable investments climate resilient*.

Climate hazards to which the sector is not sensitive are not further addressed in the vulnerability analysis. However, the scale (Table 3) provides for the possibility of assessing the "lack" of sensitivity for cases where it is necessary to distinguish between individual subsectors where some are sensitive to a climate hazard but others are not.

*Table 3. Degrees for assessing sensitivity to climate hazards*

| Sensitivity | Score in numbers | Comment |
|---|---|---|
| **High** | 3 | Climate hazards can have a significant impact on sites, processes, resources and products in the sector concerned |
| **Moderate** | 2 | Climate hazards can have a moderate impact on sites, processes, resources and products in the sector concerned. |
| **Low** | 1 | Climate hazards may have little impact on sites, processes, resources and products in the sector concerned |
| **Lack** | 0 | The sector is not sensitive (not affected) to certain climatic hazards |

#### *2.1.3.3. Assessment of the degree of vulnerability*

Formula (1) and the color matrix proposed in the methodology set out in the *Guidelines for Project Managers: Making vulnerable investments climate resilient* are used to assess the degree of vulnerability. The same three colors were used: green for low, yellow for moderate, and red for high vulnerability (Table 4).

*Table 4. Color scale for assessing the degree of vulnerability to climate hazards*

| | ***Exposition*** | | | |
|---|---|---|---|---|
| ***Sensitivity*** | | ***Low*** | ***Moderate*** | ***High*** |
| | ***Low*** | **1** | **2** | **3** |
| | ***Moderate*** | **2** | **4** | **6** |
| | ***High*** | **3** | **6** | **9** |

The numerical scale for assessing the degree of vulnerability in the application of formula (1), corresponding to the presented color matrix, is given in Table 5.

*Table 5. Numerical scale for assessing the degree of vulnerability to climatic hazards*

| **Vulnerability** | **Result of formula (1)** | **Equalization of the score on a scale of "one to three"** |
|---|---|---|
| **High** | 6 – 9 | 3 |
| **Moderate** | 2 – 4 | 2 |
| **Low** | 1 | 1 |

In order to maintain the "one to three" scale, as used in the other cases in this methodology, the estimates obtained by the formula are equated according to the last column of the table above.

When summarizing the assessment at the municipal level for the types of vulnerabilities identified at the sectoral level, only vulnerabilities with "high" and "moderate" assessment are taken into account, such as the types of vulnerabilities that fall into one assessment group, e.g. "High" are ranked according to numerical estimates before alignment.

#### *2.1.3.4. Determining vulnerability indicators*

According to the content of the mandatory form to the guidance for the preparation of the SECAP, in addition to the assessment of vulnerabilities, for each of them should be proposed and a textual definition and classified in one of the following groups: social, economic, physical or environmental.

Separately for each of the sectors, after formulating the description of the vulnerability and its belonging to one of the listed groups, for each type of vulnerability an appropriate indicator for assessment is recorded with the respective unit of measurement. If possible according to the available

data, present value and numerical limit values for the respective indicator are provided. If the available data do not allow it, if possible, an expert assessment is made, and activities related to research and evaluation of the base value and future monitoring of changes in this value will be included in the SECAP of Sofia Municipality.

When formulating the indicators, the basic rule is to be optimally consolidated so that they can be practically measurable and traceable, without having to spend significant additional financial resources.

After summarizing and ranking the types of vulnerabilities, all high-vulnerability indicators are described in a general list in section 5. A complete list of vulnerability indicators is presented in *Annex 2* of the report.

### 2.1.4. Impact assessment

The definition of the "impact" of climate hazards recorded in the form for the SECAP Development Manual reads as follows:

> ***Impacts*** *generally refer to potential effects (without adaptation) on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate change or hazardous climate events occurring within a specific time period. Impacts are also referred to as consequences.*

Impact assessments are carried out at sectoral level, separately for each climate hazard for which the sector has been identified as vulnerable.

The type of expected impact is described, and the probability of occurrence (*Table 6*) and and the expected level of impact are estimatede on a similar three-level color scale, as in other assessments, indicating the period of time in which the impact can be expected. For the assessment of the expected level of impact, an assessment in figures has been added (*Table 7*).

*Table 6. Scale for estimating the probability of occurrence of expected impact*

| **Probability** | **Definition** |
|---|---|
| **Very likely** | The impact will almost certainly appear in the specified period |
| **Probably** | The impact can be expected to appear in the specified period |
| **Unlikely** | The impact is rather not expected to occur in the specified period, but it is not excluded |

*Table 7. Scale for assessing the level of impact of climate hazards*

| Level of Impact | Score in numbers | Definition |
|---|---|---|
| **Great** | 3 | In the event of the described impact, large negative consequences can be expected on the affected persons or objects |
| **Moderate** | 2 | In the event of the described impact, small negative consequences can be expected on the affected persons or objects |
| **Low** | 1 | In the event of the described impact, insignificant negative consequences on the affected persons or objects can be expected |

The period of occurrence is classified as 'present', 'short-term', 'medium-term' or 'long-term' as defined in *Table 1* above.

#### *2.1.4.1. Determination of impact indicators*

According to the content of the mandatory form to the guidance for the preparation of the SECAP, in addition to indicators of vulnerability, indicators for the impact of climate hazards in individual vulnerable sectors should be prepared. The approach to defining and presenting the indicators is identical to the one described in section 2.1.3.4 on the definition of vulnerability indicators.

When formulating the indicators, the basic rule is to be optimally consolidated so that they can be practically measurable and traceable, without having to spend significant additional financial resources.

After summarizing and ranking the types of impact and calculating climate risks at the municipal level, all impact indicators for those identified as high climate risks are described in a general list in section 5 of the report. A full list of impact indicators is presented in *Annex 2* of the report.

### 2.1.5. Risk Assessment

Numerous scientific publications, such as *Technical paper 4: Assessing current climate risk*[5] (pp. 100), published on the website of the *United Nations Framework Convention on Climate Change (UNFCCC),* state that climate risk is a function of the probability of occurrence of an event that causes damage and its consequences.

Following this logic, for example in the SECAP of Dublin, climate risk is assessed by the formula:

*Climate risk = Probability x Consequence (2)*.

In the present analysis, the "likelihood" of an event causing damage is expressed by the "degree of vulnerability", which is a function of the frequency of the occurrence of a climatic hazard

[5] Jones, Roger, Rizaldi Boer, Technical paper 4: Assessing current climate risk, https://www4.unfccc.int/sites/NAPC/Country%20Documents/General/apf%20technical%20paper04.pdf

and the sensitivity of individual sectors to the occurrence of the relevant climatic hazard. The "consequence" is expressed by the assessment of the "degree of impact" of the climate hazard in the vulnerable sector. Therefore, the formula for climate risk assessment is:

$$R = V \times I \qquad (3),$$

where R is the climatic risk, V is the degree of vulnerability of the sector in question to the specific climatic hazard, and I is the degree of impact of the specific climatic hazard.

The risk assessment is summarized at municipal level. After summarizing the types of 'vulnerability' as described above and for each of them the assessments of the degree of impact are taken into account, according to *formula (*3) the degree of risk is calculated. For each climate hazard, the assessments for the degree of risk are summed up and the climate hazards in Sofia Municipality are ranked according to the significance of the risk.

# 3. The Climate in Sofia Municipality

## 3.1. Summary of the climate analysis in Sofia Municipality

The climate on the territory of Sofia Municipality is a result of the interaction of the three main climate-forming factors - solar radiation, atmospheric circulation and local physical and geographical features. The first two factors determine the macroclimatic features of this area. They depend on its latitude - $42^0$41' (and the corresponding amount of solar radiation entering the upper atmosphere), as well as on the main barometric centers driving the general atmospheric circulation and air masses occurring in this area - Icelandic and Mediterranean minima, and Azores and Eastern European maxima. Icelandic cyclones are observed throughout the year, but in the warm half of the year they are the reason for the formation of thunderstorms and heavy rainfall, typical of the May-June maximum rainfall in the municipality. Mediterranean cyclones, unlike Icelandic ones, are shallow, affecting the weather mainly in winter, and depending on the ways they move on, it can be warmer and drier, or colder, with above-normal rainfall. Anticyclones affect the weather depending on the season. During the warm half of the year they determine clear, quiet and dry weather with high temperatures and large daily temperature amplitudes. During the cold half of the year the weather is clear and dry, with significant radiative cooling of the ground air and the formation of temperature inversions. Precipitation in the anticyclone is insignificant.

Against the background of these common, macroclimatic features, local physiographic factors are the reason for the formation of local climatic specifics. For the territory of Sofia Municipality the main local factors that leave an imprint on its climate are the hollow shape of the relief, the orography of the fenced mountain macroslopes, as well as the urban influence on the climate. The latter has an anthropogenic character, making corrections to the effect of natural local physiographic factors. These corrections turn out to be no less important than the effect of the physiographic factors themselves.

The hollow shape of the relief is the reason for the relatively larger share of quiet weather in the area, for the lower breathability of the air basin, for the more frequent formation of inversions and retention of pollutants in the air, especially in winter. The inversions, on the other hand, are associated with lower minimum temperatures compared to other places with the same altitude, with a higher frequency of fogs, with more cases of late spring and early autumn frosts and frosts, etc.

The orography of the surrounding mountains is a factor for intensifying precipitation on windward slopes relative to the invading air masses, as well as for reducing precipitation when the slopes are in a leeward position. For example, Vitosha is in a leeward position relative to the Sofia valley in terms of air masses from the west-northwest-northern quarter of the horizon, but at the same time puts a "rain shadow" over the valley in terms of invasions from the south. In addition, the mountains transform the structure and in some cases the composition (humidity) of the air flows, having an effect on the direction and speed of the wind, and / or contributing to the generation of local winds important for urban planning and other sectors. For Sofia, such an example is the fion, as well as the mountain-valley winds. The degree of openness of the horizon, which is reduced by the orographic barriers located in the southern half of the urban horizon - Vitosha, Lyulin, Plana, Lozenska mountains - is a reason to reduce the duration of sunshine, and this is important for civic lighting, vegetation and others. In the valley itself there is also a certain heterogeneity of relief, significant in microclimatic terms.

The urbanized area has an effect on most climatic elements and processes. This is due to several main factors, including those exerted by the artificial underlying surface (urban substrate), urban morphology, polluted urban air, and others. The urban substrate, consisting of different roofing materials, absorbs and reflects solar radiation in different ways, and this affects the heat emitted by it and the corresponding heating of the ground air. Basalt and mosaic in summer absorb 15 - 16 MJ/$m^2$, while asphalt - 20 MJ/$m^2$. The air temperature in the center of Sofia is up to $1^0$C higher than its outskirts (Figure 2). Polluted air is the cause of less solar radiation reaching the earth's surface. In the warm half of the year in an urban environment this amount is reduced by up to 10%, and in the cold - by 15 - 20%. Urban morphology affects the duration of sunshine, especially in winter, when the sun is low and the closure of the horizon of urban buildings increases significantly. For example, in the central part of Sofia (Faculty of Agriculture) the sunshine in winter is 10-12 hours shorter than in the suburbs. The morphology of the city is of great importance for the orientation of wind flows and the increase or decrease of their speed. In the central part of Sofia in winter the recurrence of light winds (0.1 - 1.0 m/s) is 61.5%, while on the outskirts of the city it is 51%. In the spring this difference is maintained, and the numbers are 56% and 44% respectively, in the summer - 58% and 46%, and in the fall – 64% and 47%. These are just some of the many aspects in which the urban environment affects the climate. Figure 3 illustrates the difference between the average monthly wind speeds in the central and suburban areas.


*Figure 2. Annual course of the average monthly air temperature (T) in the central urban and suburban part and the temperature difference (D) between them*

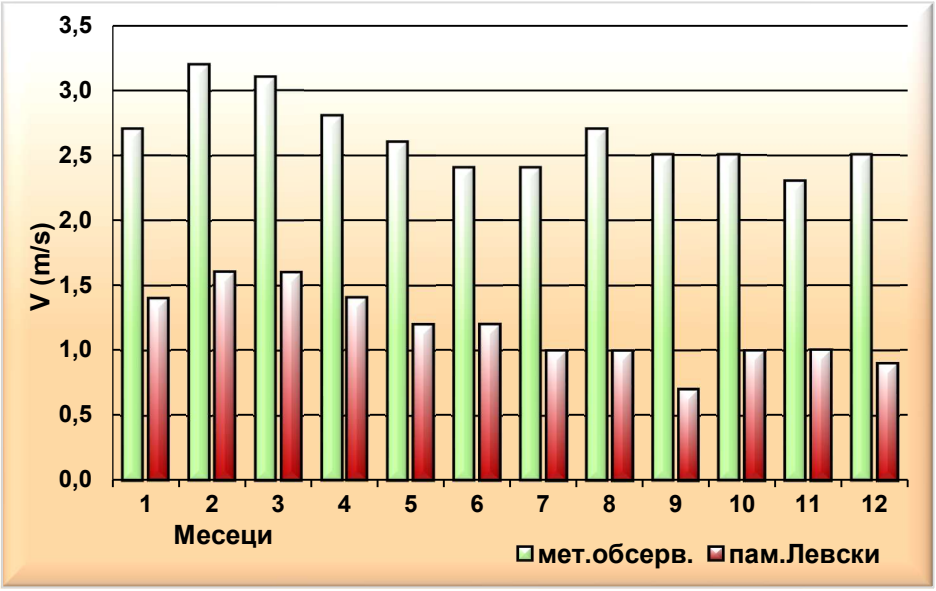


*Figure 3. Annual course of wind speed (V) in the urban and suburban part of Sofia*

Climate change is a global phenomenon with local dimensions. In Sofia the most visible are the changes (regardless of their sign) of the average and maximum air temperatures, of the fogs, of the number of rainy days, of the number of days with snowfall, of the storms, and of the wind speed. Changes in precipitation and hail are less noticeable. If current climate change trends are maintained without additional measures to mitigate and adapt to climate change, we estimate that in the coming decades the values of climate elements will change as follows:

- the average annual air temperature will increase by about 0.5 - 0.6$^0$C per decade;
- the average maximum annual temperature will increase by about 0.9$^0$C / decade;
- the annual number of foggy days will decrease by about 8 days / decade;
- the annual number of days with rainfall will increase at a slow pace - from 2.4 days / decade in 2030 up to 1 day / decade in 2100
- the annual precipitation amount will decrease hardly noticeably and with a decreasing step - from 1 mm / decade in 2030 up to 0.4 mm / decade in 2100.;
- the annual number of days with snowfall will decrease by 1.6 / decade;
- the annual number of days with storms will increase at an increasing rate - from 5 days / decade in 2030 to 10 days / decade in 2100;
- the annual number of days with hailstorm will increase, initially barely noticeable - by 0.4 days / decade in 2030, and then at an increasing rate - by 1.9 days / decade in 2100;
- the average annual wind speed will increase by 0.2 - 0.3 m / s per decade.

From the above we can conclude that the climate of Sofia has two main aspects that characterize its specificity: (a) the impact of local physiographic and anthropogenic factors, and (b) the presence of significant trends for future time horizons of some major climatic parameters. Knowledge of this specificity in detail is important in terms of a number of sectors and economic activities for which climate is important: urban environment and spatial planning, energy, renewable energy sources, water sector, transport, construction, human bioclimatic comfort, health, tourism, forestry sector, natural environment and biodiversity, agriculture, etc.

### 3.1.1. Exposition of Sofia Municipality to climate dangers

According to the adopted methodological approach, exposure to climatic hazards is defined as the degree of exposure of the subjects and objects to the adverse effects of these hazards. By applying the indicators from Table 9, each danger for SM is assessed according to the degree of its manifestations on the territory of the municipality, as well as according to the trend of their future manifestation in frequency and intensity. The results are presented in *Table 8.*

*Table 8. Exposition of Sofia Municipality to climatic dangers*

| Climatic danger | Exposition | Expected change in intensity | Expected frequency change | Period | | | |
|---|---|---|---|---|---|---|---|
| | | | | until 2023 | until 2030 | until 2050 | until 2100 |
| Extreme heat | 3 | Raise | Raise | | | | ✓ |
| Extreme cold | 2 | Reduction | Reduction | | | | ✓ |
| Temperature changes | 2 | Raise | Raise | | | | ✓ |
| Changes in precipitation | 1 | Reduction | Reduction | | | | ✓ |
| Heavy rains | 1 | Unchanged | Unchanged | | | | |
| Intense rainfall | 3 | Raise | Raise | | | | ✓ |
| Reduction of snowfall | 2 | Raise | Raise | | | | ✓ |
| Floods | 1 | Unchanged | Reduction | | | | |
| Drought | 2 | Raise | Raise | | | | ✓ |
| Storm | 3 | Reduction | Raise | | | | ✓ |
| Hail | 2 | Reduction | Raise | | | | ✓ |
| Strong wind | 1 | Unchanged | Raise | It is unknown | | | |
| Fog | 3 | Reduction | Reduction | | | | ✓ |
| Decrease the self-cleaning ability of the atmosphere | 2 | Unknown | Unknown | It is unknown | | | |
| Contrasting changes of time | 3 | Raise | Raise | | | | ✓ |
| Bioclimatic discomfort of man | 3 | Raise | Raise | | | | ✓ |
| Landslides | 1 | Unchanged | Unchanged | | | | |
| Fires (for natural reasons) | 2 | Raise | Raise | | | | ✓ |

The definitions of these climatic hazards, as well as their indicators, units of measurement and rating scales are presented in *Table 9.*

*Table 9. Climatic hazards: definitions, indicators, units of measurement, rating scales*

| Climatic danger | Definition | Indicator applied in this development | Unit | Evaluation scale of indicators | | |
|---|---|---|---|---|---|---|
| | | | | Low 1 | Moderate 2 | High 3 |
| Extreme heat | Meteorological / climatic event with significantly higher than normal values of thermal indicators. | Average annual of average maximum air temperatures ≥ 90th percentile | For frequency: % of cases with values ≥ 90th percentile in relation to the number of all cases in the studied climate series<br><br>For intensity: % of the value at the 90th percentile compared to the highest value in the studied climate series | For frequency: <5,0%<br><br>For intensity: <50,0% | For frequency: 5,0 – 9,9%<br><br>For intensity: 50,0 – 89,9% | For frequency: ≥10,0%<br><br>For intensity: ≥90,0% |
| Extreme cold | Meteorological / climatic event with significantly lower than normal values of thermal indicators. | Average annual minimum air temperature ≤10th percentile | For frequency: % of cases with values ≤ 10th percentile in relation to the number of all cases in the studied climate series<br><br>For intensity: % of the value at the 10th percentile compared to the lowest value in the studied climate series | For frequency: <5,0%<br><br>For intensity: <50,0% | For frequency: 5,0 – 9,9%<br><br>For intensity: 50,0 – 89,9% | For frequency: ≥10,0%<br><br>For intensity: ≥90,0% |
| Temperature changes | Steady changes in temperature compared to the norm for many years | Magnitude of changes in the projected average annual air temperature for future time horizons | - The magnitude of the change, measured by the product of Size x Temp, of the predicted average annual temperatures of the air by decades to future time horizons, where:<br>- Size is the difference (%) between the average annual temperature of air for the nearest future time horizon (2030) and the average annual temperature of the air for the historical period ending at the moment | For size: <5,0%<br><br>For temp: <5,0%<br><br>For magnitude: 1 | For size: 5,0 – 9,9%<br><br>For temp: 5,0 – 9,9%<br><br>For magnitude: 2 – 4 | For size: ≥10,0%<br><br>For temp: ≥10,0%<br><br>For magnitude: 6 – 9 |

| Climatic danger | Definition | Indicator applied in this development | Unit | Evaluation scale of indicators | | |
|---|---|---|---|---|---|---|
| | | | | Low 1 | Moderate 2 | High 3 |
| | | | - Rate is the average difference (%) between the forecast average year temperature every tenth future year and the next tenth year | | | |
| Heavy rains | Meteorological / climatic event with a significant amount of precipitation | Days with precipitation ≥ 25 mm | % of number of days with precipitation ≥ 25 mm, relative to the total number of days with precipitation | <5,0% | 5,0 – 9,9% | ≥10,0% |
| Intense rainfall | Meteorological / climatic event with a significant amount of precipitation for a short period of time | Annual number of days with precipitation ≥30 l / (s.ha) | % of the number of days with intensity ≥ 30 l / (s.ha), compared to the total number of days with precipitation | <5,0% | 5,0 – 9,9 % | ≥10,0% |
| Changes in precipitation | Sustainable changes in precipitation compared to the norm for many years | Magnitude of changes in the estimated annual amount of precipitation (mm) for future time horizons | The magnitude of the change, measured by the product of Size x Rate, of the estimated annual amount of precipitation by decades to future time horizons, where:<br>- Amount is the difference (%) between the annual precipitation amount for the nearest future time horizon (2030) and cf. annual precipitation amount for many years. historical period ending at the moment<br>- Rate is the average difference (%) between the forecast annual precipitation amount every tenth future year and the next tenth year | For size: <5,0%<br>Pace: <5,0%<br>For magnitude: 1 | For size: 5,0 – 9,9%<br>Pace: 5,0 - 9,9%<br>For magnitude: 2 – 4 | For size: ≥10,0%<br>Pace: ≥10,0%<br>For magnitude: 6 – 9 |
| Reduction of snowfall | Sustainable reduction of snowfall compared to the norm for many years | Magnitude of the reduction of the estimated annual number of days with snowfall for future weather horizons | The magnitude of the decrease, measured by the product of Size x Rate, of the estimated annual number of days of snowfall by decades to future time horizons, where:<br>- Size is the difference (%) between annual days with snowfall for the nearest future time horizon (2030) and cf. annual | For size: <5,0%<br>Pace: <5,0% | For size: 5,0 – 9,9%<br>Pace: 5,0 – 9,9% | For size: ≥10,0%<br>Pace: ≥10,0% |

| Climatic danger | Definition | Indicator applied in this development | Unit | Evaluation scale of indicators | | |
|---|---|---|---|---|---|---|
| | | | | Low 1 | Moderate 2 | High 3 |
| | | | precipitation amount for the historical period ending at the present moment<br>- Rate is the average difference (%) between annual days with snowfall every tenth coming year and the next tenth year | For magnitude: 1 | For magnitude: 2 – 4 | For magnitude: 6 – 9 |
| Floods | Effusion / spill large amounts of water, submerging areas that are not normally covered by water | Cases of floods for long-term period and corresponding damages | For frequency: Relative share (%) of the number of cases above the norm in relation to the total number cases for the long-term period<br>For intensity: Relative share (%) of the amount of damages (thousand BGN) above the norm, compared to the total amount of damages (thousand BGN) for the long-term period | <25,0%<br><25,0% | 25,0 – 49,9%<br>25,0 – 49,9% | 50,0 – 100%<br>50,0-100% |
| Drought | Prolonged periods with unusually dry weather, leading to severe water imbalance | Periods without precipitation lasting at least ≥10 days | Frequency: Number of non-rainy periods lasting ≥ 10 days for the April-October interval, for a multiannual period<br>For intensity: Relative share (%) of no-rainy periods lasting> 21 days, compared to all cases of drought periods (≥10 consecutive days) | ≤4,0<br><10% | 4,1 – 4,9<br>10 – 20% | ≥5,0<br>>20% |
| Storm | Disturbance in the normal state of the atmosphere, manifested by strong winds, often accompanied by rain, snow, hail, thunder and lightning, etc. | Annual number of days with storms ≥ 90th percentile | For frequency:% of cases with values ≥ 90th percentile in relation to the number of all cases in the studied climate series<br>For intensity:% of the value at the 90th percentile compared to the highest value in the studied climate series | For frequency: <5,0%<br>For intensity: <50,0% | For frequency: 5,0 – 9,9%<br>For intensity: 50,0 – 89,9% | For frequency: ≥10,0%<br>For intensity: ≥90,0% |

| Climatic danger | Definition | Indicator applied in this development | Unit | Evaluation scale of indicators | | |
|---|---|---|---|---|---|---|
| | | | | Low 1 | Moderate 2 | High 3 |
| Hail | Type of precipitation from frozen in concentric layers of rain particles falling from cumulonimbos clouds | Annual number of days with hail ≥ 90th percentile | For frequency: % of cases with values ≥ 90th percentile in relation to the number of all cases in the studied climate series<br>For intensity: % of the value at the 90th percentile compared to the highest value in the studied climate series | For frequency: <5,0%<br>For intensity: <50,0% | For frequency: 5,0 – 9,9 %<br>For intensity: 50,0 – 89,9% | For frequency: ≥10,0%<br>For intensity: ≥90,0% |
| Strong wind | Natural movement of air at speeds equal to or greater than 14 m/s | Cases with strong wind | Relative share (%) of strong winds (≥ 14 m/s) of the total number of winds | <5,0% | 5,0 – 9,9% | ≥10,0% |
| Fog | Water vapor condensed to fine water droplets or ice crystals suspended in the lower atmosphere, differing from clouds only in that they are close to the earth's surface, highly dependent on environmental factors - temperature, humidity, wind, topography, water bodies, small air particles, incl. pollutants | Annual number of foggy days ≥ 90th percentile | For frequency: % of cases with values ≥ 90th percentile in relation to the number of all cases in the studied climate series<br>For intensity: % of the value at the 90th percentile compared to the highest value in the studied climate series | For frequency: <5,0%<br>For intensity: <50,0% | For frequency: 5,0 – 9,9%<br>For intensity: 50,0 – 89,9% | For frequency: ≥10,0%<br>For intensity: ≥90,0% |
| Contrasting changes of time | Meteorological changes, characterized by a high degree of difference between the parameters of the upcoming and previous meteorological weather | Contrasting weather days | Relative share of days with contrasting change of time compared to all days | <35,0% | 35,0 – 50,0% | >50% |

| Climatic danger | Definition | Indicator applied in this development | Unit | Evaluation scale of indicators | | |
|---|---|---|---|---|---|---|
| | | | | Low 1 | Moderate 2 | High 3 |
| Decrease of the bioclimatic comfort of the person | Steady decrease of bioclimatic comfort compared to the norm for many years | Categories of time without obstructions (WO), with partial obstructions (PO) and with obstructions (O) for long stays outdoors | Frequency (%) of the manifestations of time in the categories WO, PO and O | <35,0% | 35,0 – 50,0% | >50% |
| Landslides | A natural phenomenon in which the stability of large earth masses is disturbed and preconditions are created for their movement | Active landslides | Relative share (%) of their total number | <35,0% | 35,0 – 50,0% | >50% |
| Fires (for natural reasons) | Uncontrolled combustion process in time and space, characterized by heat release accompanied by smoke and / or flames | Annual number of fires | For frequency: Relative share (%) of the number of cases above the norm in relation to the total number of cases for a multi-year period | < 25,0% | 25,0 – 49,9% | 50,0-100% |
| | | | For intensity: Relative share (%) of the amount of damages (thousand BGN) above the norm, compared to the total amount of damages (thousand BGN) for a multi-year period | < 25,0% | 25.0 – 49,9% | 50,0-100% |

# 4. Sector analyzes

## 4.1. State of the Water sector

### 4.1.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

Proper policies are being developed **at European and national level** to adapt to climate change, which are evolving dynamically. The water supply and sewerage sector is regulated and most of the criteria for service quality are directly related to the sector's adaptation to climate change.

**At the national level**, the implementation of policies to increase the "value" of water resources by encouraging the reduction of water consumption and approaches to water recycling / reuse by various stakeholders (eg local authorities, industrial enterprises, utilities, agriculture) economy, households, etc.) are not yet at the required level. There is no clear policy on how to include climatic and geographical features in the valuation of the costs for water supply services.

**At the municipal level**, there are no incentives to encourage the use of "green technologies" in urban planning and in the design of urban water supply and sewerage systems and building installations. For example, measures may be considered to implement the following good engineering practices appropriate to the urban environment: 1) Creating opportunities (through appropriate urban planning) to locally contain rainwater runoff at the site of its formation by creating artificial lakes or wetlands areas or its use for watering green areas; 2) Separate installations for "black" and "gray" water in buildings and reuse of gray water (e.g. for flushing toilets); 3) Search for opportunities to build "natural" retention volumes for flood protection due to river overflow, which will become an integral part of urban planning; 4) Educational campaigns among the population on the effect of climate change and promoting the rational use of water; 5) Economic incentives for saving water or the use of recycled water by different users (industry, agriculture, households).

#### - Economic factors

The high rate of connection of the consumers to the water supply and sewerage network, the high percentage of measured water in relation to the total invoiced water and the gradually increasing price of the water supply and sewerage service are good preconditions for reasonable use of water by consumers.

This, in turn, should be an incentive for the operator to improve the service and implement modern energy efficient and environmentally friendly solutions in the operation and maintenance of water supply and sewerage systems, which will compensate for possible reduction in revenue due to reduced consumption. However, the implementation of such solutions may lead to an increase in the cost of the service.

The socially tolerable threshold for the population of Sofia Municipality is much higher than the current prices of the water supply and sewerage service, which implies solvency of consumers and reimbursement of costs for the service. At the same time, there is a tendency among household

consumers to "realize" the need for efficient use of water and to take individual measures for this. This can be considered as a favorable social precondition for easier adaptation to climate change.

Organizing a wider educational and information campaign among the population on the challenges of climate change and the need for prudent use of drinking water, as well as increasing confidence in the quality of water in the water supply network, can contribute to a more significant reduction in water consumption in the future and easier adaptation to climate change.

### - Technological factors

Sofiyska Voda AD (water supply and sewerage systems operator of Sofia) uses and implements modern technologies in the management, operation and maintenance of water supply and sewerage systems, which is a condition for achieving very good regulatory indicators regarding the quality of water supply and sewerage services. This will facilitate easier adaptation of the service to the challenges of climate change. Despite the positive trends and the coverage of the long-term level of the indicator for total water losses (including real losses), they are still too high.

Possible future reductions in consumption may increase the risk of secondary microbiological contamination of water due to increased downtime and depletion of residual chlorine (in the network). In 2018, based on the approach specified in BDS EN 15975-2 "Safety in the supply of drinking water. Guidelines for risk and crisis management. Part 2: Risk Management" and the approach of the World Health Organization (WHO) Water Safety Plans, Sofiyska Voda AD has prepared a "Risk Assessment for Drinking Water Supply", which identifies the hazards in the watercatchment, assesses the risks to the process of production and supply of drinking water (including reduced water consumption), and determines the critical control points, which are subject to continuous control and management.

Sofia Municipality makes regular investments for the construction and maintenance of river correction facilities. A system for monitoring and early warning of floods has been implemented on the territory of the municipality, which helps to take adequate measures to mitigate or reduce this risk.

### - Environmental factors

Temperature changes, changes in the amount, abundance and intensity of precipitation, floods and droughts are climatic factors that directly affect the quality and exploitation of natural and water sources, key to the socio-economic development of Sofia Municipality. The trends outlined for these factors in Section 4 dedicated the climate in Sofia Municipality give grounds to consider them as climate hazards for the Water sector.

Regarding the floods, the exposure of Sofia Municipality is low, and the expectations for their change in terms of intensity and frequency are "no change" compared to the current situation (Table 28). According to the assessment of the Plan for management of flood risks 2016-2021, the overflow of some rivers on the territory of Sofia Municipality due to floods, will affect a small part of the building stock and the population. However, such floods can endanger human health and strategic infrastructure, and therefore appropriate protection measures need to be taken.

### 4.1.2. Assessment of the impact of the factors for the development of the Water sector for building the adaptation capacity of Sofia Municipality

*Table 10.* Assessment of the influence of the factors for development of the Water sector in building the adaptation capacity of Sofia Municipality

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 – max 5) | Comment |
|---|---|---|
| Political | 4 | There is a well-developed legal framework, which, however, is not yet fully implemented in practice. There are no incentives for the implementation of green solutions and circular economy in the design and construction of residential and building plumbing installations, as well as for efficient use of water by consumers. |
| Economic | 5 | There is a high coverage of the water supply and sewerage service and progressive development of economic activities in the municipality, but this does not lead to a significant increase in water consumption. The socio-economic environment in the municipality is a prerequisite for the return of costs for the water supply and sewerage service.<br>Reimbursement of costs for correction of riverbeds and maintenance of their operational suitability is not regulated. |
| Social | 3 | There are positive trends for a responsible attitude towards water consumption, but they are still in their infancy and with little effect. The price of the water supply and sewerage service is at a significant "distance" from the threshold of social tolerance. |
| Technological | 5 | Modern technologies for operation of water supply and sewerage networks have been introduced. There is good control of leaks and a positive trend to reduce them. |
| Environmental factors | 3 | The tendencies of change of some climatic factors give grounds to identify as climatic dangers, which can negatively affect the capacity and quality of water sources, as well as hinder the operation of water supply and sewerage systems. Intensified monitoring of water sources and improvement of water supply and sewerage systems for adaptation to climate dangers are needed. |

### *SWOT analysis on the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ High percentage of connection of the population to water supply and sewerage. There is a good provision of the water supply and sewerage service in terms of revenue.<br>▪ Sufficient database, allowing a stable assessment of the shortcomings and the potential for innovation of the water supply and sewerage systems and the engineering infrastructure related to river corrections;<br>▪ Clear programs have been developed for the renovation of the water supply and sewerage systems and the activities related to river corrections;<br>▪ There is a good implementation of the quality indicators of the water supply and sewerage service, in particular reduction of water losses;<br>▪ There are applied modern technologies for purification of natural and waste waters, which allow efficient water purification and utilization of sludge as energy raw material;<br>▪ Most of the rivers in the territory of the municipality have been corrected, which greatly reduces the risk of floods;<br>▪ The SM has a modern system for monitoring and early warning of flood danger. | ▪ The water supply and sewerage network are almost completely built, but mostly morally and physically obsolete, which is associated with high losses of drinking water and infiltration / exfiltration of the sewerage network;<br>▪ The monitoring of the sewerage network is not yet at the level of the monitoring of the water supply network; there is no assessment of infiltration or degree of filling of the hydraulic capacity;<br>▪ The modernization of the water supply and sewerage infrastructure requires high capital costs, which cannot be provided only by the water supply and sewerage operator;<br>▪ Modernization and maintenance of river correction facilities associated with significant expenditures that cannot be fully covered by the budget of Sofia Municipality;<br>▪ Bio-engineering techniques to reduce the negative impact on the environment are poorly used in the construction of river correction facilities. |
| **External factors for SM: Opportunities** | **External factors for SM: Threats** |
| ▪ Water supply and sewerage services in Bulgaria are regulated by strictly regulated service quality indicators, including criteria related to adaptation to climate change (e.g. quality of drinking water, number of complaints of floods due to insufficient sewerage);<br>▪ Tangible climate change will encourage the rational use of water resources among users of the water supply and sewerage service;<br>▪ EU and national policies and legislation stimulate the development of climate change adaptation solutions;<br>▪ EU Cohesion Funds support investment in resource efficiency and adaptation to climate change;<br>▪ The developed maps in the Plan for management of flood risks of areas with significant potential flood risk for the Iskar River valley in the Sofia valley serve as a good basis for assessing the risk areas on the territory of Sofia Municipality and taking adequate measures. | ▪ Bulgaria lags behind in the development of a strategy and action plan for the implementation of the circular economy, which has a key role in adapting to climate change;<br>▪ There are no incentives to use "green" solutions for building plumbing;<br>▪ There is no appropriate urban infrastructure planning for temporary retention and / or utilization of rainwater;<br>▪ Measures aimed at the rational use of water can reduce water consumption, which in turn would have a negative effect on the operator and operation of water supply and sewerage systems in the following areas: revenue reduction, deterioration of drinking water quality in the network, problems with clogging of sewer collectors;<br>▪ There is no clearly defined regulation to cover the costs of maintaining the technical infrastructure for river correction on the territory of the Sofia Municipality. |

## 4.2. State of the forestry and agriculture sector

### 4.2.1. Main conclusions from the analysis of the factors for the development of the sector

- **Political factors**

A common conclusion that can be made on the basis of existing strategic documents and regulations is that at European, national and municipal level there are adequate and constantly evolving policies for adaptation to climate change. The actual implementation of the policies within the Sofia Municipality is essential. Concrete steps are needed to detail measures to adapt Sofia's green system to the challenges of climate change.

- **Economic factors**

From an economic point of view, measures to adapt the forestry and agriculture sectors to climate change are of low expected value. This can be seen as a positive factor. There are opportunities to seek external funding for forestry, agriculture and green system activities of Sofia Municipality.

- **Social factors**

The presence of strongly contrasting but clearly expressed opinions about the values of nature and green spaces in Sofia Municipality can be considered as an opportunity to clearly define the need for significant improvement of activities for the development and maintenance of natural components in Sofia Municipality. This is a prerequisite for increasing the share of projects aimed at improvements and their funding. At the same time, it can be considered in terms of very good opportunities for implementing policies to adapt to climate change and implementing plans for new parks and increasing afforested areas.

- **Technological factors for the development of the sector**

Adapting forestry, agriculture and landscaping to the challenges of climate change is largely independent of technological factors. Many of the potential measures are rather related to political and managerial decisions and their implementation. The improvement of the condition of the equipment used in forestry and agriculture and the maintenance of the green system in the settlements can have a potentially positive impact. The modernization of the technical park, especially in agriculture, leads to increased efficiency and at the same time reduced greenhouse gas emissions. It is essential to improve the condition of the green system of Sofia and other settlements and to improve the possibilities for permanent or periodic watering.

The development of computer and information systems can significantly facilitate and improve the collection of necessary information, its analysis, and hence the planning and improvement of forest management, agricultural land and green systems of settlements. In this regard, it is essential to build a detailed digital register of trees and the overall green system of Sofia, and it is best to use the capabilities of GIS systems. To reduce the risk of large-scale losses from natural disturbances, especially fires, it is important to improve the systems for monitoring and early detection of natural

disturbances and response to them. To quickly control forest fires, it is essential to significantly improve the equipment and the provision of trained firefighting personnel in hard-to-reach areas.

### - Environmental factors for the development of the sector

The most important for the Agriculture and Forestry sector are the factors related to the environment and climate. Vegetation develops in the context of all environmental factors, the most important being factors related to altitude, topography, baseline and soil conditions and local climatic conditions. In this respect, the territory of Sofia Municipality is very diverse due to the mountainous terrain of the mountains surrounding the Sofia valley. This determines the large number of forest habitats. Altitudes of 400 m above sea level up to 2290 m above sea level (Cherni Vrah Peak) are present, as the city of Sofia is at 500-600 m above sea level.

In terms of expected climate change, the most significant potential risks to ecosystems are related to:

- **Expectations of an increase in the frequency and severity of summer droughts**, which, combined with rising temperatures, are likely to cause significant stress to a number of more sensitive plant species and therefore have the potential to cause serious damage and loss. Droughts are also directly related to the increase of the risk of large, large-scale and difficult to control forest fires, similar to the one in 2012 in the Bistishko Branishte Reserve.
- **The expected increased risk of more frequent and severe storms** is also directly related to potential significant damage to forests (wind and subsequent insect calamities), serious losses of agricultural production and damage to elements of the green system of settlements. A very significant example in this respect are the significant losses from the wind storm in May 2001 on the territory of Vitosha National Park and the subsequent invasion of a European spruce bark beetle. Combined, they caused unprecedented damage to the territory of Sofia Municipality in coniferous forests. Almost every year in Sofia there are storms with torrential rains and strong winds that knock down city trees or damage their branches, which poses an additional risk to human life and health and damage to property. There is a similar risk of **wet and heavy snowfall,** especially if it is associated with the onset of an autumn storm with still available leaves of deciduous species. Although **freezing rains** are rare in the Sofia region, such cases exist and it is possible that during the warming winters and the inversions characteristic of this period with low temperatures in the Sofia valley, such cases will become more frequent. Such events have the potential to cause very serious damage to woody plants.

The large amplitude of sharp droughts in summer, hail, floods, frosts due to lack of snow cover in winter lead to extreme conditions for growing crops. This may require providing irrigation conditions in summer and drainage during the autumn-winter and spring seasons.

### 4.2.2. Assessment of the influence of the factors for development in the sector "Forestry and agriculture" for building the adaptation capacity of Sofia Municipality

*Table 11. Assessment of the influence of the factors for development in the sector "Forestry and agriculture" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 – max 5) | Comment |
|---|---|---|
| Political | 4 | There is a well-developed legal framework, which, however, is not yet fully implemented in practice. Additional commitments to concrete actions are needed |
| Economic | 4 | The cost of measures to adapt the sector to climate action is relatively low and external funding may be sought |
| Social | 4 | There is a partially negative attitude towards the management of the green system of Sofia, but at the same time there is an interest in improving this management. There are opportunities with small intensity and value measures to improve the attitude of society. A potential increase in green and wooded areas would be approved by a large part of the population |
| Technological | 3 | No significant and costly technical innovations and improvements are needed to achieve a significant impact in terms of adaptation to climate change. There is a need to improve the information base to improve the planning and decision-making and management of the implementation of adaptation measures |
| Environmental factors | 2 | Environmental and climate factors are the main determinants of the risk of climate change. They are difficult to influence. Well-planned and implemented adaptation measures are needed to reduce vulnerability |

#### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ Well-developed regulatory framework regarding forest management with the availability of adaptation measures and plans and commitments through the FSC certification process;<br>▪ Well-developed adaptation analysis for agriculture and forests to the National Strategy for Adaptation to Climate Change and Action Plan (2019);<br>▪ Existence of a Climate Change Adaptation Strategy for Sofia Municipality and a Climate Change Adaptation Plan for Sofia Municipality;<br>▪ High percentage of landscaping on streets and parks in parts of Sofia;<br>▪ Developed modern production base and accumulating experience in the production of forest planting materials and the presence of nursery gardens and local companies with experience in the field. | ▪ Delayed measures for expropriation of land from the green system and potential conflicts in the implementation of planned activities;<br>▪ Unclear and insufficiently developed normative base for management of elements of the green system;<br>▪ Lack of a well-developed Register of Green Areas and Filed Vegetation to allow analysis and planning. |

| External factors for SM: Opportunities | External factors for SM: Threats |
|---|---|
| ▪ EU and national policies and legislation stimulate the development of climate change adaptation solutions;<br>▪ Significant public interest in the topic of improving the condition of forests and green areas and reducing potential losses from extreme weather events;<br>▪ Low expected levels of investment to implement adaptation measures with potentially significant positive effects;<br>▪ Opportunities to find external funding for adaptation measures;<br>▪ Opportunities for absorption of significant amounts of carbon when creating new afforestations, especially in the context of completing the system of Green Wedges of Sofia. | ▪ Bulgaria lags behind in the development of a strategy and action plan for the implementation of the circular economy, which has a key role in adapting to climate change;<br>▪ A number of risks associated with climate change with unclear possible effects such as magnitude on forest ecosystems and agriculture. |

## 4.3. State of the Urban Planning Sector

### 4.3.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

A significant number of current international policy documents provide a clear framework for action in the field of urban planning; working forms of international cooperation between cities have been established.

A process of updating the national framework of spatial planning is underway, bringing the planning documents in line with modern urban concepts and approaches; this is a good opportunity to integrate climate change considerations, requirements and measures.The main challenge is the development of strategic documents for integrated planning and overcoming sectoral approaches.

There is an urgent need for an explicit focus on building the appropriate institutional and expert capacity at the municipal level.

#### - Economic factors

Urban planning aims to guide the construction, operation and management of urban and regional living environment, which will provide optimal bioclimatic comfort for people working and living in the city, which are the main driving force for the economic development of the capital.

Significant information gaps hamper in-depth research into the side effects of extreme weather events.

Management and use of urban land - with a more limited perspective in valuing land as a commodity and making maximum profit from it, instead of a broader perspective on valuing land as a scarce resource that should meet a set of tangible and intangible needs of urban residents, including the adaptation to climate change. The structural technical and economic indicators in Law on the spacial development and construction of the Sofia Municipality (built area, treated area, percentage of

landscaping), in the Spatial Development Act and in the by-laws presuppose unfavorable models and parameters of construction.

Public investment in critical primary and secondary infrastructure (including housing, transport, etc.) resistant to extreme weather events is still an isolated practice - action and economic resources for adaptation to climate change need to be foreseen in urban development plans and other planning tools.

The dependence of the big city on many goods, which are delivered from near and far, points to the topic of its food security. In addition to activating local communities, the development of urban agriculture requires systematic methodological and financial support.

### - Social factors

Based on the available information, it can be concluded that the current state of the urban system of Sofia creates conditions for the deepening of historically determined and emerging new socio-spatial divisions in the city. This poses a risk of increasing the social vulnerability of the city to the expected climate change and requires explicit attention to the aspects of social vulnerability in determining the priority actions of the SM for the adaptation to climate change. When prioritizing action to adapt to climate change, two interrelated principles of democracy need to be taken into account - the distributive one - "distribution of goods and goods?", and the procedural one - "who decides?".

### - Technological factors

Unfortunately, despite the steps taken by the Municipality, so far Sofia is lagging behind in the application of intelligent technological systems for research, management and development of the urban system. Bridging this gap requires providing the necessary resources for research and development at the national level, as well as a comprehensive assessment of the strategic benefits of building institutional capacity and expertise.

### - Environmental factors

The changes in the land cover, land use and morphology of the city over the last two decades are in the direction of deteriorating the microclimate in terms of the formation of urban heat island, ventilation flows and retention of air pollution. On the one hand, the widely used after the restitution of the land model of th medium and high-rise building along the street regulatory lines has a negative impact. On the other hand, the increase in the area for transport, including traffic and stay (parking), has a negative impact due to the increased motorization and dependence on the personal car as a change in the model of movement. Other demographic and socio-economic factors are also having a negative impact, moving the city towards more significant land use and its compaction and intensive construction. Some of the changes may have some minimal positive effects in the event of significant climate change in the direction of warming through the shadows cast by densely built-up neighborhoods and the formation of new urban street canyons.

### 4.3.2. Assessment of the influence of the factors for development in the sector "Urban planning" for building the adaptation capacity of Sofia Municipality

*Table 12. Assessment of the influence of the factors for development in the sector "Urban planning" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 3 | Urban planning has been the focus of a number of policy documents at global and European level, with an explicit emphasis on its role in achieving the goals of sustainable development and climate change adaptation (CCA).<br>The sector is included and is discussed in detail in the National Strategy of the Republic of Bulgaria for CCA. The updated national laws and regulations regarding urban planning include texts confirming their compliance with global and European documents on CCA.<br>Insufficient synchronicity between the formulation of strategic documents at the local level creates conditions for mutually contradictory practices and inefficient use of public resources. |
| Economic | 2 | There are no sufficiently developed economic incentives and there are no targeted resources to include adaptation to climate change in the overall life cycle of urban development - from spatial planning (especially at the level of Detailed Development Plan and in relation to relevant development indicators), through investment design and construction of urban infrastructure (buildings and facilities) to the operation and possible reuse of the already developed and built-up urban environment.<br>The predominant in most cases short-term economic interests related to maximum market profit seriously hinder the discussion and implementation of adequate long-term measures for the CCA. |
| Social | 1 | The observed increase in social stratification and socio-spatial segregation creates inequalities in access to a clean environment and a favorable climate. Energy poverty and relatively higher climate vulnerability are observed in social and age groups living in different parts of the city and in different forms of living - both single-family and multi-family buildings.<br>There is a predominant dependence on conventional energy sources and suppliers. Updating the legal requirements would allow for a more flexible approach in the implementation of innovative common, group and individual solutions that contribute to the CCA.<br>Recognition of social problems requires finding appropriate solutions in plans and projects for intervention in the urban environment - individual (owners, households) and collective (condominiums, institutions, public).<br>The involvement of a growing number of NGOs and individual experts in the process is indicative of a growing public awareness of the importance of the issue, but achieving sustainable results requires systematic support at all levels of government. |
| Technological | 2 | Despite the efforts made for the introduction of modern information technologies (including GIS) in urban planning and management, there is still a general lag in research and development and technological activities in the sector.<br>The availability of financial support for building a sustainable urban environment through operational and research programs funded by the EU and other sources creates an opportunity for practical action to synchronize between planning by institutions, businesses and |

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| | | households in the energy transition to technological innovation, including as related to CCA. |
| Environmental factors | 3 | The relatively favorable regional natural and climatic conditions of Sofia Municipality are in many cases compromised by persistent negative trends in urban development (e.g. excessive and intensive high-rise construction in attractive parts of the city, near green wedges or even within them). This worsens the overall access to a clean environment, the conditions for ventilation and cooling, the provision of even landscaping and water areas in the open urban space.<br>Better synchronization of the measures applied by different institutions to achieve specific urban planning parameters would contribute to their greater efficiency.<br>A favorable factor is the growing active public support for nature conservation and improving the quality of the urban environment as factors for a healthy lifestyle. |

### *SWOT analysis on the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ **Political** - the presence of managerial will and steps taken to implement the European provisions of the CCA in the strategic documents of urban planning<br>▪ **Economic** - metropolitan center with its own resources to take action for CCA and energy transformation<br>▪ **Social** - relatively high civic awareness regarding environmental protection and CCA in Sofia<br>▪ **Technological** - continuous improvement of geo-spatial information; (developed strategy for digitalization of SM)<br>▪ **Environment** - favorable characteristics of the natural (surrounding mountains) and historically built (structure, morphology, building materials) environment. | ▪ **Political** - lack of specificity and synchronicity in the developed and adopted documents in relation to the CCA (measures, indicators, funding, etc.); lack of mechanisms to promote CCA measures; Insufficient institutional and expert capacity for implementation of integrated urban policies, incl. for CCA<br>▪ **Economic** - lack of economic attitudes and investment culture for the implementation of long-term and comprehensive measures; lack of a framework and mechanism for assessing the side costs and benefits of ecosystem services<br>▪ **Social** - the presence of groups at risk of poverty (including energy); fragmented property in the housing sector - difficult implementation of CCA measures (lack of environmental justice, health challenges, etc.); spatial segregation<br>▪ **Technological** - general lag in the application of basic technological innovations in the construction sector (concept of life cycle, integrated assessment methods, bioclimatic architecture)<br>▪ **Environment** - temperature inversions, urban sprawl, increased density and intensity of construction, fragmentation of the green system / infrastructure, "shrinking" of open public spaces. |
| **External factors for SM: Opportunities** | **External factors for SM: Threats** |
| ▪ **Political** - long-term strategic framework of the EU and the Republic of Bulgaria; access to European educational and research cooperation for integrated planning and management<br>▪ **Economic** - access to European funding for a sustainable urban environment | ▪ **Political** - adverse consequences for the big cities of Eastern Europe from the negotiations on the multiannual financial framework of the EU (including the Green Deal)<br>▪ **Economic** - reduction of available financial resources due to global and European processes and the expected economic crisis<br>▪ **Social** - migration to Sofia from the country and abroad, increasing climate and other related refugee flows |

| | |
|---|---|
| ▪ **Social** - changing attitudes and practical experience in spatial planning and investment design due to growing connectivity in the European space<br>▪ **Technological** - access to funding for technological innovation (Horizon Europe program, etc.). | ▪ **Technological** - low quality of the technical characteristics of the built environment. |

## 4.4. Situation of the Civil Protection Sector

### 4.4.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

There are enough normative documents regulating the activities in the sector. Unfortunately, they have very limited opportunities in the context of climate change and its impact on the sector. There are no assessments, strategies and guidelines to take into account the impact of the Civil Protection sector on reducing emissions, reducing them, using new modern signaling technologies, automatic fire extinguishing, prevention and safety of buildings, facilities and the public. The main regulations are based on long-established fire safety requirements, evacuation plans, disclosures, etc.

#### - Economic factors

The Civil Protection Sector is developing in the conditions of lack of financial resources, trained staff, application of modern technologies and human resources. Compared to other EU countries, the technological equipment of the sector is insufficient - there is no modern control center, technological monitoring equipment, modern communication systems and more. The available Aerospace Center has a shortage of software and hardware, trained personnel and effective communication with the public.

#### - Social factors

The social perception of the activity of the sector is at a very good level. The population takes into account the efforts of the leadership, the rapid response to crisis situations (floods, fires, landslides, etc.), the communication of management with the media, efficiency in general. However, the reaction of the population and the effectiveness of civil protection in extreme crises remains unknown - explosions of ammunition depots, mass fires, chemical accidents, severe earthquakes, prolonged drought, prolonged rainfall leading to floods, possible rupture of dam walls along the Iskar Cascade and others. An essential component is the correct and timely communication with the media, social networks and other high-tech means of information transfer.

#### - Technological factors

Technologies in the development of society in relation to the sector are conservative and slowly changing. This leads to a relatively stable trend of gradual and slow change in the number of fires. Other extreme phenomena in the sector are characterized by relatively low recurrence of high intensity (e.g. earthquakes). Earthquakes are often a source of secondary negative phenomena, such as landslides, ruptures of the earth's crust, destruction and many fires. In this sense, the construction

of early warning systems can be useful especially if they are equipped with circuit breakers for gas distribution network, chemical plants, thermal power plants and others. However, these systems are expensive and low-performance, as strong earthquakes in our country are rare. However, the establishment of monitoring systems for monitoring and managing risk phenomena is essential to increase the efficiency of the Civil Protection sector.

Another important direction for highly efficient activity of the sector is the use of different scenarios, playing out real situations through simulation (i.e. modeling of dangerous phenomena and processes with real data), verification and corrections for mistakes.

The use of coordinated remote monitoring systems (drones, low-orbit and high-resolution satellites, real-time GIS systems, GPS devices, high-speed internet, etc.) is essential for modernizing civil protection in combating climate risks.

Firefighting technologies are evolving more dynamically. The wide penetration of foams, carbon dioxide mixtures, etc. burden the environment with greenhouse gases. Unfortunately, controlling carbon dioxide and other toxic gases is virtually impossible in the event of a fire. In this sense, prevention is a major factor, but it is an expensive and difficult to manage activity.

#### - Environmental factors

The main environmental impacts in the context of climate change in the sector can be expected mainly from fires and their impact on the environment as a major source of carbon dioxide. Carbon emissions in the sector are generated both by emerging fires in the urban environment of Sofia and by some of the methods for extinguishing them. Recently, mixtures for extinguishing highly flammable liquids with carbon dioxide and foams have been used. They are a source of additional carbon load.

### 4.4.2. Assessment of the impact of development factors in the Civil Protection sector for building the adaptation capacity of Sofia Municipality

*Table 13. Assessment of the impact of development factors in the Civil Protection sector for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 3 | There is a good regulatory framework for the development of the sector. However, the estimates for carbon emissions generated in the sector are completely neglected. |
| Economic | 2 | In the conditions of stagnation, the proposed measures are expensive, difficult to achieve and difficult to justify. General prevention can also be used in extreme situations. |
| Social | 4 | Favorable social perception. Uncertainties about extreme phenomena leading to mass fires. |
| Technological | 3 | Strong technological development is needed in line with the global trends. |
| Environmental factors | 4 | Multifactorial and multidirectional impact, difficult to assess in the sector. |

***SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats***

| | |
|---|---|
| **Internal factors for SM: Strengths**<br>▪ Centralized structure (easier to manage);<br>▪ Existence of expert capacity for crisis response;<br>▪ Existence of capacity to cover the activity in the media and in the public. | **Internal factors for SM: Weaknesses**<br>▪ Limited financial resources allocated for the development and prevention sector;<br>▪ Lack of databases for analysis of the influences of various factors on the development of the sector;<br>▪ Lack of training programs for the population. |
| **External factors for SM: Opportunities**<br>▪ European funding programs;<br>▪ Opportunities to use positive practices;<br>▪ Lack of training programs for the population. | **External factors for SM: Threats**<br>▪ Lack of executive and organizational capacity to receive outside assistance in extreme situations. |

## 4.5. State of the Environment and Biodiversity sector

### 4.5.1. Factors for the development of the sector

#### - Political factors

In the EU, but especially in Bulgaria, the public awareness of the problems related to the disruption of the functions of the ecosystem as a whole (and not only of individual species and individuals) is relatively low. One of the main reasons is the lack of specialized ecosystem legislation.

In addition, Bulgaria does not yet have a functioning biodiversity strategy, which makes it difficult to formulate and implement policies in the sector at the municipal level.

Despite these difficulties, Sofia is well positioned to be a multifunctional and smart city in which green infrastructure is an integral part of the urban environment. Potential difficulties may arise due to the role of the city as a user of ecosystem services related to the CCA (mostly related to water production and climate regulation), which are created in neighboring municipalities, protected areas and territories or are subordinated to other state bodies.

#### - Economic factors

Bulgaria as a whole and Sofia in particular face a number of challenges related to the lack of a private initiative for conservation and restoration of ecosystems. As a result, the economic cost of regulatory and cultural ecosystem services crucial for adaptation may be too high if the restoration of the ecosystems providing them begins after their damage and loss of such services.

Sofia has the political will and some well-established local instruments, but they are not always enough to overcome the strong economic interests for unsustainable use of natural resources. The new Taxonomy Regulation and the implementation of the Green Deal in general have the potential to help address this issue.

#### - Social factors

The realization of the full social potential in the sector is mostly limited by public attitudes towards the environment as a lower priority area and in some cases an obstacle to economically viable activity.

Sofia Municipality is well positioned to optimally realize the social benefits of the enhanced creation and provision of ecosystem services for adaptation to climate change.

### - Technological factors

A significant part of the unrealized scientific and technical potential is concentrated in Sofia and the creation of eco-innovations can be supported through appropriate municipal initiatives and close cooperation with the scientific community.

### - Environmental factors

Sofia is the region with the strongest urbanization pressure, linked to the city's attractiveness as a center of business and employment, education, innovation and policy-making. In this regard, it is imperative to use the approach of ecological red lines for optimization.

## 4.5.2. Assessment of the impact of development factors in the sector "Environment and Biodiversity" for building the adaptation capacity of Sofia Municipality

*Table 14. Assessment of the impact of development factors in the sector "Environment and Biodiversity" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 3 | The municipality is taking a number of steps beyond the national strategic framework, but in the new programming period, national political support is needed for environmentally friendly adaptation as part of the European Green Deal. |
| Economic | 2 | The available economic potential is sufficient, but it is necessary to create incentives to direct it to the sector |
| Social | 4 | The municipality has approved green initiatives. The challenge is to create better "visibility" for ecosystem benefits, especially for vulnerable groups, who in many cases are not interested in the environment. |
| Technological | 3 | Technological and innovation potential is available, but not yet intensively focused on biodiversity conservation |
| Environmental factors | 4 | Not all territories where ecosystem services necessary for the municipality are created are under its jurisdiction |

### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ Unique natural location close to large-scale ecosystems with the potential to support adaptation | ▪ Impossibility to significantly expand green infrastructure in the areas of greatest demand (especially heat islands, polluted air areas) |

| | |
|---|---|
| ▪ Urban planning of Sofia with large green areas and inter-block spaces<br>▪ Preserved parks with old trees and well-planned water areas<br>▪ Traditions in involving the population in landscaping and cleaning the city, e.g. Green Sofia project<br>▪ A clear and progressive vision for the future of the city, incl. approved climate change adaptation strategy | ▪ Uncertainty about preserving green wedges<br>▪ Insufficient support from business and society for a coherent green policy<br>▪ Economic initiatives for unsustainable urbanization due to high prices of housing and non-residential buildings<br>▪ Need to create a single data platform suitable for reuse in different thematic analyzes |
| **External factors for SM: Opportunities**<br>▪ Opportunities which can be developed in the direction of voluntary environmental monitoring and the creation of ecosystem services (e.g. in the framework of the European Pollinator Initiative)<br>▪ Untapped potential for recreation in the areas around Sofia<br>▪ Insufficiently used potential for ecological agriculture, agroecology<br>▪ Potential for strong synergies with innovative sectors such as IT, robotics, mechatronics (for ecosystem monitoring), space research (for remote monitoring)<br>▪ Untapped opportunities for restoration of wetlands outside NATURA 2000 or creation of artificial wetlands with multidirectional use<br>▪ An increasing amount of publicly available and open data<br>▪ Concentrated scientific potential, incl. for ecosystem research, space observations, modeling, etc. | **External factors for SM: Threats**<br>▪ Lack of a national strategy for biodiversity and a correspondingly low priority for its conservation, incl. in shaping the position on the European Green Deal<br>▪ The increased attractiveness of Sofia as a place to live and the strong labor migration increase the pressure on urban ecosystems<br>▪ Strong fragmentation of protected areas outside NATURA 2000 and difficult access for connectivity if different owners are not convinced to maintain ecological corridors<br>▪ High water losses mean withdrawal of water resources from ecosystems in the areas of water supply zones and downstream of the Iskar River<br>▪ Sufficiently good data exchange with monitoring institutions in the municipality has not yet been ensured |

## 4.6. State of the waste sector

### 4.6.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

European policies to adapt to climate change in the waste sector are focused on preventing and minimizing waste, resource recovery and drastically reducing landfills. National legislation is in line with European legislation, but there is no active process of implementing and enforcing effective separate collection for quality recycling, and there are no financial mechanisms to motivate the understanding of waste as a resource. Recovery of biodegradable waste is key to limiting biogas emissions from landfills and mitigating climate impacts. Sofia Municipality has adopted a municipal program and ordinance in accordance with the Waste Management Act and is gradually implementing the measures set out in them, but it is necessary to update the waste management program for the new EU programming horizon and in line with the global sustainable development goals set in UN Agenda 2030.

#### - Economic factors

The introduction of the principles of the circular economy and the perception of waste as a resource gives impetus to the development of waste management activities. The share of collected

recyclable waste, which is returned as raw material in other industries, is growing. Investing in modern facilities and systems is not a panacea and should be accompanied by the promotion of prevention, reuse and separate collection in order to reduce operating costs. The principle of payment according to quantity should be the guiding principle in determining the municipal waste tax. Waste disposal is the lowest in the hierarchy of the management and should be minimized not only due to the risk of soil, groundwater and surface water pollution, but also to prevent the formation of methane gas from the decomposition of organic waste deposited in them.

### - Social factors

The fee for household waste in the municipality for households is determined on the basis of the tax assessment of the property. At the moment, the tax can be considered socially tolerable, but work should be done to link it to the amount of waste that households recycle. This will have a social and economic effect on the entire waste management system, but implies a high commitment of households and systematic work for their information and control by the administration. Preventing the illegal incineration of heating waste by vulnerable groups in society is key to health, the environment and the climate. The introduction of separate collection of bio-waste from households will contribute to the reduction of landfilled quantities and, accordingly, to the reduction of biogas generation, which can contribute to climate change mitigation.

### - Technological factors

Sofia Municipality is the first municipality in Bulgaria to apply modern technologies in waste management - anaerobic decomposition of food waste with energy production; large-scale composting, mechanic-biological treatment of mixed household waste, incl. RDF production. All these efforts aim to drastically reduce the disposal of biodegradable waste, which facilitates easier adaptation to the challenges of climate change.

### - Environmental factors

- **Temperature changes**

With regard to the management of outdoor waste, the increase in temperature leads to an acceleration of the decomposition of organic waste and the release of unpleasant odors. For example, raising the temperature of a landfill can cause self-ignition and unwanted fires. In this sense, compliance with the requirements for minimizing landfilled biowaste; the technological regime of gradual filling in waste cells; the requirements for densening/compaction of waste in order to eliminate the access of air/oxygen in the landfill; regular clogging with at least 20 cm of intert materials, would prevent risky situations.

A situation of a sharp drop in temperature can again affect the processes for outdoor waste. For example, access to waste containers, their collection and transport to treatment facilities, as well as the disposal process itself can be difficult.

- **Heavy / intense rains, floods**

Landfills in operation (Dolni Bogrov and Sadinata) can be most affected by torrential rains if they are not implemented in accordance with the project and do not follow the technology for filling and compacting the cells in height. Modern landfills are basically insulated with geomembranes so as

to prevent groundwater contamination. They have built drainage systems to collect the formed infiltrate and pumping systems for its return to the body of the landfill or wastewater treatment plant before discharging them into a water intake or water body. However, there are registered cases in the country during torrential rains and a sharp rise in water levels in rivers and ravines to lead to a complete compromise of landfill cells, incl. removal of the deposited masses outside the boundaries of the landfill. For the closed landfills (Suhodol), where correct technical and biological reclamation has been made, the sensitivity to floods is low.

### 4.6.2. Assessment of the influence of the factors for development in the sector for building the adaptation capacity of Sofia Municipality

*Table 15. Assessment of the influence of the factors for development in the sector "Waste" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 4 | There is well-developed legislation, programming documents and action plans that can incorporate measures to adapt the waste management sector to climate change. There is no political will to introduce effective separate collection of household waste. |
| Economic | 3 | It is necessary to introduce a Municipal Waste Fee, linked to the amount of separately collected waste. Effective recycling is at the heart of the circular economy. |
| Social | 2 | Targeted, systematic efforts by the administration are needed to change the public understanding of waste as a resource and to change people's behavior. |
| Technological | 4 | Modern technologies for waste treatment have been introduced, but it is necessary to load the installations at full capacity. Recovery of RDF fuel is an opportunity to prevent the generation of greenhouse gases from landfilled waste. |
| Environmental factors | 4 | Heavy rains have the greatest negative potential on waste management infrastructure, but technology plans can be improved to minimize negative effects. |

#### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ Existence of biowaste treatment plants corresponding to the best available techniques and technologies, ensuring the production of quality compost and energy.<br>▪ Recovery of part of the combustible waste as RDF-fuel.<br>▪ Systematic efforts are being made to install home composting bins in predominantly low-rise neighborhoods.<br>▪ The share of separately collected recyclable waste is constantly growing and the municipality has achieved the goals for recycling. | ▪ Biowaste plants are loaded to less than 50% of their capacity.<br>▪ There is no active process of implementing and enforcing effective separate collection of biowaste from households.<br>▪ There are no financial mechanisms to motivate the understanding of waste as a resource.<br>▪ RDF production is significantly below the capacity of the installation.<br>▪ The amount of landfilled waste is decreasing, but at an insufficient pace. |

| | |
|---|---|
| ▪ Conditions have been created for the implementation of a project for utilization of RDF works.<br>▪ A waste management information system has been introduced.<br>▪ The SM has built capacity to develop, finance and implement projects for the waste management | ▪ No new programming document for the waste management has been adopted - the validity of the Municipal Waste Management Program expires in 2020. |
| **External factors for SM: Opportunities**<br>▪ European policies, programs and funds supporting projects and activities for adaptation to climate change and the circular economy.<br>▪ Support of the European Commission for the implementation of the project for Installation for cogeneration in Sofia with recovery of RDF waste | **External factors for SM: Threats**<br>▪ The consequences of COVID 19, deepening the economic and financial crisis. Non-fulfillment of the expected revenues from the Municipal Waste Fee. |

## 4.7. State of the Building ssector

### 4.7.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

To date, the building sector has not been considered significant at European and national level in terms of the need to implement climate change adaptation activities. Following the adoption of the European Green Deal in 2020, increasing attention will be paid to the design and construction of buildings in compliance with the principles of the circular economy and their resilience to climate change.

Some international voluntary building standards, such as BREEAM, LEEAD, SMARTER Finance - "Green Home and Green Mortgage", etc., have already established requirements and criteria for the application of these principles in building construction and can serve as an example for future upgrades of national and local regulatory documents related to the requirements for design, construction and operation of buildings to improve their resilience to climate change.

#### - Economic factors

In the new construction of buildings there is a stable growth rate, which is mainly due to housing construction, as the main economic factors are: the presence of a sufficient size of the population with purchasing power corresponding to variuos price segments on the market; a well-developed mortgage market and the availability of sufficient financial resources; as well as the availability of workforce, corresponding to the level of established traditions and quality in construction.

The new requirements for the Building sector resulting from the political factors described in the previous point imply the introduction of different approaches to construction from the traditional, requiring higher-quality construction, the use of new materials and modern installations, for which the construction sector is not prepared, as the lack of staff with the necessary qualifications,

as well as training programs for acquiring such qualifications, will be acutely felt. The same conditions are needed in order to be able to perform quality "deep" energy renovation of existing buildings.

### - Social factors

The gradual wider penetration of buildings with nearly zero-energy consumption and "green" buildings will significantly improve the conditions of the microclimate in buildings, which will have a positive impact on human health, comfort in general, and the productivty of the occupants of these buildings. However, a relatively small part of the municipality's population will have access to such new housing.

The poor condition of residential buildings is one of the reasons why the country has the highest level of energy poverty in the European Union. Deep energy renovation is a tool that can help reduce the problem of energy poverty.

It is extremely important in determining the conditions of the future programs for financial support of housing renovation to analyze the level of income of the population and to propose differentiated conditions of support for different social groups.

### - Technological factors

The imposing of significantly higher requirements on the energy performance of buildings, as well as the gradual increase in the frequency of construction of new "green" buildings requires the introduction of new approaches in the design and construction process and the careful use of new technologies, materials and equipment, such as:

- integrated design
- orientation of the building
- glazing
- thermal bridges
- architectural details
- air tightness
- high efficiency windows
- mechanical ventilation with highly efficient heat recovery
- shading
- installations for the use of energy from renewable sources
- additional environmental criteria for "green" buildings.

### - Environmental factors

Buildings and infrastructure can be vulnerable to climate hazards, for example due to their construction (e.g. low storm resistance), energy performance (e.g. high heat losses through enclosures), architectural solutions (e.g. lack of shading against direct sunlight in summer), or location (e.g., in areas prone to floods or landslides). Floods and landslides (after earthquakes) are the types of disasters with the greatest material damage and this is especially true mainly in densely built-up areas. However, Sofia Municipality has a low exposure to these dangers, and they also affect relatively small densly built-up areas.

In the capital, there are growing problems with overheating of the built environment, exposed to rising temperatures and extreme heat, which is not only a problem for the building materials, but also affects the comfort and health of the occupant. Fires can also undoubtedly cause great damage to buildings. However, statistics show that fires that are due to natural causes are very few compared to the number of fires related to human activity.

In the relatively short term, the main threats to construction and buildings may arise from: (1) torrential and intense rainfall, which is increasingly common in Sofia, for example leading to water intrusion, property damage and, in rare cases, damage to foundations and basements, demolition of buildings and infrastructure; (2) extreme summer overheating events, in an extent leading to material fatigue and accelerated aging, reduced comfort and potentially bad health consequences, high energy consumption for cooling, etc.

### 4.7.2. Assessment of the influence of the factors for development in the sector "Buildings" for building the adaptation capacity of Sofia Municipality

*Table 16. Assessment of the influence of the factors for development in the sector "Buildings" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Politically | 3 | In accordance with the requirements of the Energy Efficiency Directive and in accordance with the National Plan for Buildings with Nearly Zero Energy Consumption 2015-2020, from the beginning of 2021, the mandatory requirement for new buildings to meet the national definition of nearly zero-energy buildings should enter into force. However, the necessary regulatory framework has not yet been prepared. |
| Economically | 4 | The construction of buildings is developing at a stable rate of growth and has a well-developed real estate market. In connection with the new challenges posed by the political framework, innovative approaches in construction will require higher-quality construction, the use of new materials and modern installations, for which the construction sector is not prepared. The lack of adequately qualified staff will be felt, as well as the lack of curricula for acquiring adequte qualification. |
| Social | 3 | It is extremely important in determining the conditions of the future programs for financial support of housing renovation to introduce high requirements in terms of energy performance of buildings, mandatory citizen participation, as well as to analyze the level of income and offer differentiated conditions of support for different social groups. |
| Technological | 3 | New approaches in the design and construction process and the use of new technologies, materials and equipment will have to be carefully considered: integrated design; orientation of the building; glazing; thermal bridges; architectural details; air tightness; high-efficiency windows; mechanical ventilation with highly efficient recuperation; shading; installations for the use of energy from renewable sources; additional environmental criteria for "green" buildings. |
| Environmental factors | 4 | The buildings sector is relatively less vulnerable to the climatic hazards inherent to the territory of Sofia Municipality, compared to many other sectors. The highest degree of vulnerability is determined in relation to storms and torrential and heavy rains. |

### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ Stable growth rate in new construction of buildings, dominated by housing construction. There are a number of favorable economic factors such as: the presence of a sufficiently large part of the population whose purchasing power corresponds to the different price segments on the market; well-developed mortgage market and the availability of sufficient financial resources; the availability of labor, corresponding to the level of established traditions and quality in construction. All this is a prerequisite for a gradually growing part of the population of Sofia Municipality to start living in new and more efficient buildings.<br><br>▪ At present, a relatively small part of the residential buildings in Sofia have been renovated, while a few buildings where this has been done have been renovated to the minimum required levels of energy efficiency. This can also be seen as an advantage, because the potential for implementing measures for "deep" energy renovation of most buildings is still preserved. | ▪ The new high building requirements stemming from the EU's energy and climate policy framework will unfortunately meet the construction sector largely unprepared. Although it has been regulated for about a decade that after 2020 all new buildings should have nearly zero-energy consumption, not all the necessary conditions have been created in this period to ensure a smooth transition from traditional construction to the construction of high-efficiency and "green" buildings. As a result, it is still necessary for designers and construction workers, managers and control bodies to become acquainted with the principles and new construction practices that should be applied. The necessary new materials and equipment are more difficult to find on the market and at prices much higher than in EU, due to the lack of sufficient demand so far.<br><br>▪ Sofia Municipality, as well as the state administrations, are renovating the buildings they own most often according to the minimum requirements regarding the energy characteristics and mainly with funds from grant programs. In this way, the opportunity to make the most of the energy saving potential of these buildings is missed.<br><br>▪ With the National Programme for Energy Efficiency of the Multifamily Residential Buildings and the full grant provided to the participants, an unrealistic attitude was created among a large part of the population that the state will solve the problems with the efficiency of their housing. This can be a serious obstacle to a large-scale "deep" renovation of residential buildings. |
| **External factors for SM: Opportunities** | **External factors for SM: Threats** |
| ▪ The latest EU policy framework, introduced through the adoption of the Green Deal, places higher demands on buildings not only in terms of their energy performance but also in terms of their resilience to climate change, and pays attention to compliance with the principles of the circular economy in construction. In this regard, changes in national regulations are forthcoming. Sofia Municipality will have the opportunity and responsibility through enhanced control to ensure compliance with these high requirements, which can achieve a significant improvement in comfort and microclimate, as well as the energy performance of buildings.<br><br>▪ A new national program for the renovation of residential buildings is also expected to be prepared. If it is prepared reasonably, in a way that attracts the participation of private capital, creating special conditions to encourage the participation of people on lower incomes and setting criteria to stimulate finding the most effective solutions for renovation, the program can become the basis for the gradual "deep" renovation of the entire housing stock.<br><br>▪ The gradual wider penetration of buildings with nearly zero-energy consumption and "green" buildings will significantly improve the conditions of the microclimate in buildings, which will have a positive impact on human health, comfort in general, and the productivity of the occupants of these buildings. Private standards for | ▪ A significant obstacle to achieving a higher level of efficiency in the renovation of buildings would arise if, at national level, the tendency to set minimum criteria for energy performance in funding programs and not to stimulate cost-effective "deep" renovation of buildings is maintained.<br><br>▪ A possible delay at the national level in introducing the new requirements related to the energy performance of buildings will limit the amount of results achieved from the application of the requirements in practice. |

| | |
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| certification of buildings allow investors to add value to the buildings they build as an asset. | |

## 4.8. State of the Transport sector

### 4.8.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

Adaptation to climate change is becoming increasingly important in European and national transport policy. However, there is a lack of systematic studies on the long-term impact of climate change on the transport sector in Bulgaria. Similarly, the definitions of specific activities for adaptation to climate change and their effects in the transport sector need more attention and research.

For the current programming period 2014-2020, all transport infrastructure projects applying for grants from the EU Cohesion and Structural Funds must have an assessment of adaptation to climate change.

Sofia Municipality timely addresses the problems related to adaptation to climate change through the Strategy for Adaptation to Climate Change adopted in 2016, as well as the subsequent Plan for Adaptation to Climate Change.

#### - Economic factors

Despite the visible efforts of Sofia Municipality to renovate public transport vehicles and create comfort and convenience when traveling, it can be seen that the car continues to be a preferred vehicle especially for work and business travel.

The investment potential and the number of employees in the capital are expected to remain stable, which is favorable for more effective adaptation to climate change.

The investments planned in the Sustainable Urban Mobility Plan until 2035 for the renewal of public transport vehicles, construction of new metro sections, construction of cycling and pedestrian infrastructure, as well as the introduction of intelligent transport systems will have a significant impact on mitigating climate change and climate adaptation.

#### - Social factors

A key condition for the influence of social factors is the accessibility and connectivity of the city. In recent years, large investments have been made in Sofia Municipality in the construction of the metro and the renovation of the transport infrastructure and public transport vehicles.

The development of the bicycle network will make cycling more attractive and contribute to more effective adaptation to climate change. Bicycle transport has a very high degree of flexibility, which makes it usable even in situations of disasters and accidents that would compromise rail and road transport.

### - Technological factors

Technology will change the way urban mobility is used and planned. Technology-based innovation will be key to meeting the challenges of energy and climate change in the sector.

To meet the challenges of the times, Sofia Municipality must build a new model of urban mobility based on sustainable forms of transport and open to technological innovation.

### - Environmental factors

Transport, due to the specific nature of the implementation of its object of activity, is characterized by direct exposure and dependence on natural geographical conditions, including climatic factors and conditions. There are a number of climate factors that could potentially affect transport infrastructure and services in the future. The main conclusions of the "Analysis and assessment of the risk and vulnerability of sectors in the Bulgarian economy to climate change" are that in general the transport sector can be classified as extremely sustainable for the period until 2035, but the capacity for adaptation is insufficient. The high resilience of the transport sector is due firstly to the expected moderate climate change by 2035 and secondly to the fact that the transport system is designed and built taking into account local climatic conditions.

The Strategy for Adaptation to Climate Change of Sofia Municipality identifies the following main climate risks for the transport system of Sofia:

- Floods of the underground infrastructure (metro and subways);
- Violations in the power supply of traffic control systems, trolleybuses, subways, private vehicles (due to floods, cold and other extreme weather factors);
- Inconveniences for users of the transport system (due to service disruptions).

As a result of the analysis, the following specific risks for the transport system of Sofia Municipality have been identified:

- Violation of the transport pavement at high temperatures and respectively increased risk of accidents and incidents;
- Increasing the discomfort of citizens in urban and suburban transport;
- Risk of increased road accidents due to more intense rainfall;
- Increased need for cooling of personal cars with air conditioners, which leads to higher than normal fuel consumption and correspondingly higher emission values;
- Risk of damage to road infrastructure due to more intense rainfall;
- Risk of interruption of access from/to remote areas due to damaged road infrastructure, distressed areas;
- Delays and/or interruptions in the supply chain due to climatic factors.

The following climatic factors are considered to have a positive effect:

- Higher winter temperatures will reduce the risk of icing of the transport infrastructure, as well as the retention of snow cover, which will reduce the associated costs;
- Higher winter temperatures and less icing and snowing of roads will lead to fewer road accidents due to poor road conditions;
- Less icing, as well as snow retention, will lead to fewer delays and / or interruptions in the supply chain.

### 4.8.2. Assessment of the influence of the factors for development in the sector "Transport" for building the adaptation capacity of Sofia Municipality

*Table 17. Assessment of the influence of the factors for development in the sector "Transport" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 4 | Adaptation to climate change is becoming increasingly important in national and municipal transport policy. In a number of strategic documents, Sofia Municipality is implementing more and more measures that are focused on climate adaptation. |
| Economical | 5 | There are good economic and financial preconditions for the implementation of measures for adaptation to climate change in the sector. The investment potential and the number of employees in the capital are expected to remain stable, which is favorable for more effective adaptation to climate change. |
| Social | 4 | A key condition for the influence of social factors is the accessibility and connectivity of the city. In recent years, large investments have been made in Sofia Municipality in the construction of the metro and the renovation of the transport infrastructure and public transport vehicles. The development of the bicycle network will make cycling more attractive and contribute to more effective adaptation to climate change. |
| Technological | 4 | Technology-based innovation will be key to meeting the challenges of energy and climate change in the transport sector. The introduction of intelligent transport systems in the sector will improve the capacity to assess information related to climate and climate risks. |
| Environmental factors | 3 | Well-planned and implemented measures aimed at climate adaptation are needed to reduce vulnerability. Not all climate change has a negative impact on the transport sector. Higher winter temperatures will reduce the risk of icing of the transport infrastructure, as well as the retention of snow cover, which will reduce the associated costs and provide more opportunities for mobility (pedestrians, cyclists). |

#### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ In a number of strategic documents, Sofia Municipality is implementing more and more measures in the Transport sector, which are focused on climate adaptation.<br>▪ Well-developed public transport, offering bus, tram, trolleybus and metro services.<br>▪ 99.7% of the residents are within walking distance from a public transport stop.<br>▪ The infrastructure projects implemented on the territory of the municipality under the operational programs "Growing Regions", "Transport and Transport Infrastructure" and "Environment" 2014-2020 have been assessed for adaptation to climate change. | ▪ High degree of motorization. Old and unecological fleet.<br>▪ Lack of a complete and connected bicycle network. There is still no comprehensive bicycle sharing system in place.<br>▪ Insufficient connectivity between pedestrian areas<br>▪ Low speed public transport. Poor condition of the tram infrastructure.<br>▪ Need to build more bus lanes to prioritize bus public transport.<br>▪ Accessibility of the public transport system - not all public transport vehicles are yet low-floor. Improving accessibility to stations and metro stations. |

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| ▪ There is a policy to promote electric mobility - electric cars park for free in the paid hourly parking areas, and are exempt from local taxes.<br>▪ There are good economic and financial preconditions for the implementation of measures for adaptation to climate change in the sector.<br>▪ Existence of an investment program with measures to promote sustainable urban mobility until 2035. A plan for sustainable urban mobiblity has been adopted.<br>▪ Existence of intelligent transport systems for more efficient management of transport systems and infrastructure.<br>▪ Sofia Municipality timely addresses the issues related to adaptation to climate change through the Strategy for Adaptation to Climate Change adopted in 2016, as well as the subsequent Plan for Adaptation to Climate Change, in which the Transport Sector is also present.<br>▪ The share of vehicles with alternative fuels (electric and natural gas) and low-emission, meeting the Euro VI standard in the bus fleet of the capital's public transport is growing.<br>▪ By 2025, all buses from the capital's public transport are expected to be air-conditioned, which will improve the adaptation capacity to high temperatures.<br>▪ Tariff policy in public transport, which provides price relief to a number of social groups and encourages the use of long-term subscription plans.<br>▪ Existence of a park and travel scheme in the buffer car parks to the metro.<br>▪ Increasing the scope of hourly paid parking areas. | ▪ Poor condition of sections of the secondary street network.<br>▪ Insufficiently developed charging network for electric vehicles.<br>▪ Lack of introduced low-emission zones in which to limit the access of cars. |
| **External factors for SM: Opportunities**<br>▪ Stable political and macroeconomic environment with prudent and predictable fiscal policy.<br>▪ Existence of a National Strategy for Adaptation to Climate Change and an Action Plan with measures specifically targeted at the Transport Sector.<br>▪ In the following programming periods, all transport infrastructure projects applying for grants from the EU Cohesion and Structural Funds must have been assessed for adaptation to climate change.<br>▪ The investment potential and the number of employees in the capital are expected to remain stable, which is favorable for more effective adaptation to climate change.<br>▪ Existence of a good business environment for entering the market of new companies to offer shared electric cars, as well as micromobility: e-scooters and e-bikes.<br>▪ Higher winter temperatures will reduce the risk of icing of the transport infrastructure, as well as the retention of snow cover, which will reduce the associated costs and provide more opportunities for mobility (pedestrians, cyclists).<br>▪ Compact city with high density - favors pedestrian and bicycle traffic. | **External factors for SM: Threats**<br>▪ Increased frequency of climate adverse events, which will lead to increased economic losses for the transport sector.<br>▪ Damage to transport infrastructure due to climatic hazards and disasters.<br>▪ Climate hazards for key services, including food delivery, reduced mobility and accessibility (or at higher costs)<br>▪ Lack of statistics on traffic accidents due to the impact of climatic hazards, as drivers are obliged to take into account the atmospheric conditions, the condition of the road, the specific conditions of visibility (Art. 20 of the Traffic Act).<br>▪ The high price of electric cars prevents their wider uptake.<br>▪ Lack of tax breaks at national level or other forms of subsidies for vehicles using alternative fuels.<br>▪ Concentration of logistics and forwarding warehouses around Sofia Airport. |

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|---|---|
| ▪ Opportunity for integration of the transport documents for public transport between Sofia Municipality and BDZ - Passenger Transport EOOD (the Bulgarian state railway service) for transport on the territory of the municipality. | |

## 4.9. State of the Tourism sector

### 4.9.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

At the global and European level, systems of indicators have been developed to monitor the sustainable development of tourism in all its aspects, including adaptation to climate change, but their monitoring is voluntary.

The EU system of indicators for sustainable development of tourism at the destination level (ETIS) is applied in Bulgaria (in the Danube region and Burgas region), as well as in Sofia. The monitoring systems of the National Strategy for Sustainable Development of Tourism of the Republic of Bulgaria and the Strategy for Development of Sofia as a Tourist Destination are developed almost entirely on the basis of ETIS, and for Sofia the established baseline values for 2015 are indicated.

At the national level, the significance of the potential impacts of climate change on the tourism sector is recognized, but no policy for adaptation to climate change has yet been developed.

#### - Economic factors

At the national and municipal level there are not enough public funds for planning and implementing measures to adapt the tourism sector to climate change.

A significant part of the enterprises in the tourism sector purposefully invest in measures to limit climate change, but a very small part takes initiatives to adapt to them.

The share of employees in the tourism industry in Sofia is relatively high, but with the assumption that the majority of employees are not aware of the problem and do not have the necessary education and qualifications to take appropriate action;

In the capital there are educational institutions in the field of tourism, which can be involved in raising the level of awareness of employees in the sector and in which in different forms can be directed the attention of students to the problem.

#### - Social factors

There is a lack of research on the impact of climate change on the tourism sector, especially in Sofia Municipality, as well as research on the relationship between climate factors and tourism efficiency.

The level of awareness of those employed in the tourism sector about the potential risks of climate change is relatively low, and it can be assumed that this also applies to the representatives of the administration.

The tourism sector maintains partnerships with local authorities and other stakeholders, for which there are several platforms - Advisory Council on Tourism to the Mayor of Sofia Municipality and in the future - the Organization for Management of Sofia Tourist Region.

### - Technological factors

Energy efficiency measures in tourism enterprises are very popular, the main problem being the continuous monitoring of energy consumption.

Water saving measures are largely implemented in tourist sites, and there is a variety of technological solutions.

In the future, the practice of winter sports on Vitosha will require the production of artificial snow, the economically justified production of which will require the most efficient use of the necessary water and energy.

### - Environmental factors

Of all the natural components, the greatest influence on all types and forms of tourism has the climate, which in turn is determined by the geographical location and topography of the destination. During all recreational activities, tourists are in a specific air environment with characteristic microclimatic elements. The features of the climate that have the greatest impact on humans are called bioclimate. It is manifested by various indicators - air temperature, humidity, degree of pollution, atmospheric pressure, duration and strength of sunshine, strength and direction of winds, period and duration of snow cover retention, cloudiness, fog, etc. Very important for the practice and for the general physiological state of man are not the individual climatic elements, but their manifestation in unity at a given moment or during a given day. It is the long-term local weather regime as a combination of temperature and humidity, wind, clouds, presence or absence of meteorological phenomena - rain, snow, storms, etc., that reflects the real state of the lowest atmospheric layers and the structure of the local climate (different weather classes) and allows to reveal the climatic and recreational potential of a given territory[6].

Tourism is also vulnerable to climate change risks arising from extreme events such as heat waves, extreme rainfall and floods[7]. These are unpredictable phenomena and as they can significantly affect tourism activities, they will have an impact on short-term travel (day trips and short breaks), earlier departures (tourists return home), and on choosing a destination for a longer stay.

A very important feature of the climate is the seasonality in the manifestation of its elements. Seasonality has a great influence on tourist development and largely determines the

[6] Асенова, М. Климатът на Източна Стара планина като условие за развитието на рекреацията. Год. на СУ „Св. Кл. Охридски“, кн. 2 – География, т. 84, 1992.
[7] Kreft, S., David Eckstein, Lukas Dorsch, and Livia Fisher, L. 2016. “Global Climate Risk Index 2016: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014.” https://germanwatch.org/en/download/13503.pdf

attendance of tourist destinations. The main climate changes affecting tourism are primarily related to changes in temperatures and precipitation in spatial and temporal (seasonal) aspects.

Climate has a major impact on operating costs, such as heating and cooling, snow removal, irrigation, food and water supply, and insurance costs[8]. As environmental conditions are an important resource for tourism, a wide range of climate-induced environmental changes will have profound implications for tourism at local and regional destination level. Changes in water availability, loss of biodiversity, deteriorating landscape aesthetics, altered agricultural production (e.g. for culinary and wine tourism), increased natural hazards, erosion and floods, damage to infrastructure and increasing disease rates will be reflected in different degrees of tourism.

### 4.9.2. Assessment of the influence of the factors for development in the sector "Tourism" for building the adaptation capacity of Sofia Municipality

*Table 18. Assessment of the influence of the factors for development in the sector "Tourism" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 2 | There is no developed policy for adapting the tourism sector to climate change, but the municipality has tested the system of indicators for sustainable tourism development, which are embedded in the monitoring system of the Tourism Development Strategy in the capital. |
| Economic | 3 | There is a lack of public funding for measures to adapt to climate change. The private tourism sector is committed to investing in climate change mitigation with its own and borrowed funds, but most likely due to the worsening pandemic, it will refrain from such costs in the coming years. |
| Social | 2 | There is a lack of research on the impact of climate change on the tourism sector, and the level of awareness of employees is relatively low. On the positive side, there are established partnerships with stakeholders as a basis for future joint action. |
| Technological | 4 | Good knowledge and relatively high level of introduction in tourism enterprises of new technologies for efficient use of water and energy. |
| Environmental factors | 2 | No preventive measures have been taken by the tourism sector (both private and public) against extreme weather events. The measures taken are mainly in response to such phenomena. |

[8] Simpson, M.C., Gössling, S., Scott, D., Hall, C.M. and Gladin, E. (2008) Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices. UNEP, University of Oxford, UNWTO, WMO: Paris, France.

***SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats***

| | |
|---|---|
| **Internal factors for SM: Strengths**<br>▪ Existence of a Tourism Development Strategy of Sofia as a tourist destination;<br>▪ Availability of indicators for monitoring the development of tourism in relation to climate change | **Internal factors for SM: Weaknesses**<br>▪ Lack of monitoring the development of the derived indicators |
| **External factors for SM: Opportunities**<br>▪ Development of new products - climate change, in certain aspects can be a prerequisite for more sustainable, more efficient and more balanced development of tourism through year-round utilization of resource potential;<br>▪ Development of new markets - withdrawal of tourists from traditionally attractive destinations due to global climate change may lead them to Bulgaria and Sofia. | **External factors for SM: Threats**<br>• Lack of a national concept for adaptation of the tourism sector to climate change<br>• Climate change is leading to an increase in extreme natural phenomena and disasters that cannot be foreseen and their manifestation may lead to the withdrawal of tourists. |

## 4.10. State of the Human health sector

### 4.10.1. Main conclusions from the analysis of the factors for the development of the sector

#### - Political factors

At European, and in recent years also at national and regional level, good policies have been established to adapt to climate change in the health sector, which are developing dynamically. The Ministry of Health should play a more active role in developing policies for adaptation to climate change and exercising control over adaptation activities. The Municipality of Sofia has an active interest and activity on the issues of adaptation to climate change, including the adoption of measures in the health sector. The implementation of the policies in this area is just starting, so it is too early to make an analysis of the effectiveness of the planned measures.

#### - Economic factors

Regarding the economic factors influencing the possibilities for adaptation of Sofia Municipality to climate change in the healthcare sector, the city of Sofia is rather placed in a privileged position compared to other municipalities in Bulgaria. Better financial opportunities of the municipality and higher average income of its inhabitants, better provision of medical staff and facilities, medical colleges, better media coverage provide good opportunities for implementing measures to adapt to climate change in the healthcare sector.

#### - Social factors

There are both favorable social preconditions for easier adaptation to climate change (e.g. higher level of information and education of the population, lower share of people from the vulnerable group over 60, etc.) and some features specific to the capital that put it at a disadvantage in this regard (e.g. large numbers and population density, leading to dense housing and increasing the effect of the heat islands, a larger share of the population of some vulnerable groups, etc.).

Targeted efforts are also needed to organize a wider educational and information campaign among the population on the impact of climate change on public health.

### - Technological factors

Sofia has the most modern medical technology base in the country, which provides an opportunity for adequate and competent response to risky - from a meteorological point of view - situations in the health sector.

Sofia Municipality supports many technological innovations that are relevant to improving the urban environment with direct or indirect effects on climate and human health.

These factors would facilitate the adaptation of the health sector to the challenges of climate change.

The technical factors in the sector include some features of urban planning and building stock, which pose both challenges and opportunities for municipal authorities in taking action on climate change and human health.

### - Environmental factors

Of the considered climatic dangers, the cases of extremely hot weather can be pointed out as the greatest threat to the health of the inhabitants of Sofia. Although not located in an area with frequent heat waves, the large population and the small number of air-conditioned homes make the capital particularly vulnerable to such adverse weather events. In Sofia, as a city of millions, the effect of the "heat island" is very clearly observed, which further increases the risk for those living in the central parts of the city. With global warming, the frequency of this natural phenomenon is expected to increase. It is necessary to pay special attention to the development of a municipal action plan in hot weather - in order to warn citizens about the dangers of extremely hot weather and propose measures to protect the population in heat waves.

Cases of extreme cold are also a danger to public health, especially for the chronically ill, the elderly, low-income people, unheated households, people from minorities, outdoor workers, the homeless, etc.

## 4.10.2. Assessment of the influence of the factors for development in the sector "Human health" for building the adaptation capacity of Sofia Municipality

*Table 19. Assessment of the influence of the factors for development in the sector "Human health" for building the adaptation capacity of Sofia Municipality*

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Political | 4 | Only in the last few years we have been working actively to develop the legislative framework, develop strategies and programs that include the health sector. The planned measures have yet to be implemented. |

| Factors for the development of the sector | Assessment of adaptation capacity (min 1 - max 5) | Comment |
|---|---|---|
| Economic | 5 | There are good economic and financial preconditions for the implementation of measures for adaptation to climate change in the health sector. |
| Social | 3 | There are both favorable social preconditions for more effective adaptation to climate change, and some specific features of the capital, which put it at a disadvantage in this regard. A large part of the population, as well as health professionals, still underestimate the negative impact of climate change on human health |
| Technological | 4 | Here is the most modern medical technology base in the country, which provides an opportunity to respond to climatic hazards. Technological innovations related to the improvement of the urban environment with a direct or indirect effect on human health are supported. There is a need for improvements in infrastructure, buildings, distribution of green areas and limiting their overdevelopment, etc. |
| Environmental factors | 3 | Warming is already having a negative effect by increasing the frequency and intensity of heat waves, which pose a risk to the health of the population of Sofia. |

### *SWOT analysis of the development of the sector - strengths and weaknesses, opportunities and threats*

| Internal factors for SM: Strengths | Internal factors for SM: Weaknesses |
|---|---|
| ▪ Good regulatory and institutional framework for implementing policies for adaptation to climate change in the health sector;<br>▪ Good opportunities for cross-sectoral cooperation with national and other regional institutions;<br>▪ There are a number of favorable economic factors, such as better financial opportunities of Sofia Municipality to take measures for adaptation to climate change in the health sector, commitment to programs and projects that have a direct or indirect effect on adaptation to climate change and on human health - such as supporting green businesses and green transport, building the metro, renewing the fleet of low-emission buses, etc.). Better opportunities for adaptation at the individual level of the residents of Sofia due to their higher standard of living and educational level;<br>▪ Better technical equipment in the health sector, better provision of medical staff per capita and higher qualification of those employed in the health sector compared to other settlements in the country.<br>▪ Larger than the national average share of the young population, which has better adaptation opportunities to climate change.<br>▪ Good media provision, which enables an effective information campaign on the risks of climate change on human health among citizens, politicians and medical professionals. | ▪ Some demographic and socio-economic characteristics make the city of Sofia particularly vulnerable to climate change in the health sector - such as the large population; high population density, high absolute number of people at risk, such as children under 5, pregnant women, elderly people working outdoors, working in conditions of overheating and/or hypothermia, taking drugs and alcohol, the homeless, people living on the top floors of flat-roofed buildings, low-income people, etc.<br>▪ Presence of a strong "heat island" in the central parts of the city and in densely built-up complexes, intensifying the effect of heat waves in summer.<br>▪ Uneven distribution of green areas in the city (the latter mitigate the effect of the city's warm island in summer). Due to the intensive construction in recent years, the areas occupied by greenery are progressively decreasing. |

| External factors for SM: Opportunities | External factors for SM: Threats |
|---|---|
| ▪ Good funding opportunities for programs and projects in the field of adaptation to climate change and clean air by the European institutions. In the future, after the adoption of the Green Pact, there will be even greater opportunities in this direction.<br>▪ The activities under the National Strategy for Adaptation to Climate Change with an Action Plan, some of which concern Sofia, are expected to start.<br>▪ There are opportunities for active collaboration of Sofia Municipality with ministries, agencies, research institutes and health institutions in the implementation of policies for adaptation to climate change in the health sector. | ▪ Compared to other European (and not only) countries, Bulgaria is late in drafting its National Strategy for Adaptation to Climate Change with an Action Plan, which provides for measures to adapt to climate change in the health sector. Some of these measures are not supported by the Ministry of Health and, accordingly, no funding is currently provided for them.<br>▪ The introduction of some adaptation measures in the sector is lagging behind - such as drawing up a plan for protection of the population in hot waves, which directly affects the residents of Sofia.<br>▪ There is a shortage of qualified staff in the interdisciplinary field of climate change and health.<br>▪ There is not enough close inter-institutional cooperation in the sector and coherence of activities.<br>▪ Neglecting the problem of the negative impact of climate change on human health on the part of citizens and insufficient attention on the part of health institutions. |

# 5. Analysis and generalized evaluation

## 5.1. Vulnerability of Sofia Municipality to climate change and climate risks

### 5.1.1. Vulnerability to climate change

According to the assessments of the degree of vulnerability in the individual sectors, a total of 17 of the 18 types of climate hazards identified in the Sofia Municipality exposure assessment (see Table 9 in Section 2) have been identified to be sensitive in at least one sector. The only climatic danger for which no sensitivity has been determined in any of the studied sectors is *Decrease in the self-cleaning ability of the atmosphere.*

The predominant estimates of the degree of vulnerability are for moderate levels, but a total of 33 vulnerabilities with a high degree have been identified in the various sectors studied. **The largest number of vulnerabilities were identified in the sectors "Human Health" and "Tourism"** - a total of 17 types of climate hazards from the exposure of Sofia Municipality. **The same two sectors, together with the Urban Planning sector, have the highest number of high-level vulnerabilities** - 7. Oppositely, with the lowest number of vulnerabilities to the climatic hazards to which the territory is exposed, is the Water sector. with a total of 6 identified vulnerabilities. The lowest number of high vulnerabilities was reported in the sectors "Water", "Buildings" and "Waste" - only one.

The review of the assessments of the degree of vulnerability by type of climate hazards reveals that three types of climate hazards stand out, for which a high degree of vulnerability has been determined in the individual sectors - ***heavy rains, storms, and extreme temperatures***. The highest scores of vulnerability are in terms of heavy rainfall - a total of 7 out of 9 sectors surveyed.

***Heavy rains*** are the climatic hazards to which absolutely all studied sectors have been identified as vulnerable. The same goes for ***heavy rains and floods***. However, high levels of

vulnerability have been identified only in the Forestry and Agriculture sector, and floods have not been identified in any sector.

*Changes in precipitation* are the climatic risks to which a vulnerability has been identified only in the Water sector, and a vulnerability to a *decrease in snowfall* has been identified in only two sectors. On the other hand, in the Tourism sector, the degree of vulnerability to *snowfall reduction* is defined as high.

*Temperature changes, changes in rainfall, floods, hail, landslides and fires due to natural causes* are climate risks to which no sector is identified with a high degree of vulnerability.

*Table 20* summarizes all the assessments of the degree of vulnerability in the individual sectors.

*Table 20. Summary of sectoral vulnerabilities to climate hazards*

| Climate hazard | Water | Forestry and agriculture | Urban planning | Environment and biodiversity | Waste | Buildings | Transport | Tourism | Human health |
|---|---|---|---|---|---|---|---|---|---|
| Extreme heat | | | | | | | | | |
| Extreme cold | | | | | | | | | |
| Temperature changes | | | | | | | | | |
| Heavy rains | | | | | | | | | |
| Intense rainfall | | | | | | | | | |
| Changes in precipitation | | | | | | | | | |
| Reductions in snowfall | | | | | | | | | |
| Floods | | | | | | | | | |
| Drought | | | | | | | | | |
| Storm | | | | | | | | | |
| Hail | | | | | | | | | |
| Strong wind | | | | | | | | | |
| Fog | | | | | | | | | |
| Contrasting changes of weather | | | | | | | | | |
| Decreased bioclimatic comfort | | | | | | | | | |
| Landslides | | | | | | | | | |
| Fires (due to natural causes) | | | | | | | | | |
| Snowfall / Snow cover / Wet snowfall * | | | | | | | | | |

* *The climatic danger for Sofia Municipality caused by climate change, which is defined in section 4. "Climate in Sofia", is "Reduction of snow cover". However, the Transport, Urban Planning, Forestry and Agriculture and Environment and Biodiversity sectors are moderately vulnerable to snowfall / snow cover / wet snowfall, which are climate hazards but not are identified as a consequence of climate change.*

According to the unified form of GCMCE for presenting the results of the SECAP for the identified vulnerabilities, their belonging to one of the predefined categories should be indicated: "physical", "social", "economic" or "environmental". In most cases, identified vulnerabilities can be classified into more than one category. The following 3 tables summarize the identified high vulnerabilities in the individual sectors to the indicated classifications, as the categories "social" and "economic" are grouped into "socio-economic".

*Table 21. High physical vulnerability of Sofia Municipality to climate risks*

| Climate hazard | Vulnerability description |
|---|---|
| **Heavy rains** | **The Urban Planning sector** is highly vulnerable to consumers and assets located in low and flat places near slopes and areas with large catchments and limited capacity of rainwater containers. Also important for the level of vulnerability are the fragmented implementation of measures for river correction and drainage without retaining and neutralizing volumes in certain parts of the currents. |
| **Intense rainfall** | **The Urban Planning sector** is highly vulnerable to consumers and assets located in low and flat places near slopes and areas with large catchments and limited capacity of rainwater containers. Poorly developed neighborhoods are also particularly vulnerable. Also important for the level of vulnerability are the fragmented implementation of measures for river correction and drainage without retaining and neutralizing volumes in certain parts of the currents.<br>**The Building sector** is highly vulnerable to heavy rainfall, involving large amounts of water entering the low and underground levels of buildings located in the lower parts of the rain-affected part of the city and/or entering the attic spaces and floors of buildings.<br>**The Transport sector** is highly vulnerable to heavy rainfall, which can cause damage to the underground transport infrastructure of the metro and subways and can lead to interruptions and delays in public transport. Disturbances in the power supply of traffic control systems, tram, trolleybus and metro are also possible.<br>**The Tourism Sector** is highly vulnerable to heavy rains, leading to: damage / destruction of the tourist infrastructure, buildings, transport infrastructure, cultural and historic heritage sites; there is a need for higher insurance costs. |
| **Reduction of snowfall** | **Sector Tourism** is highly vulnerable to shortening the period suitable for skiing on Vitosha, due to lack of snow and water for the production of artificial snow, but without much effect on tourism activities in the city. |
| **Storm** | **The Urban Planning Sector** is highly vulnerable as per building envelopes, technical infrastructure, urban furnishings and public works elements, streets and other public spaces, especially around poorly maintained high-rise buildings;<br>**The Building sector** is highly vulnerable to intense storms with very strong winds, accompanied by rain and thunder, which can cause damage to poorly fortified buildings and parts of buildings, and cause the felling of trees and branches on buildings. |
| **Strong wind** | **The Urban Planning Sector** is highly vulnerable to building envelopes, technical infrastructure, urban furnishings and public works elements, streets and other public spaces, especially around poorly maintained high-rise buildings. Groups with specific diseases are particularly vulnerable. |
| **Contrasting changes over time** | **Sector Tourism** is highly vulnerable to fog due to health problems among tourists; also, this climate hazard sets prerequisite for avalanches on Vitosha in winter. |

*Table 22. High socio-economic vulnerability of Sofia Municipality to climate risks*

| Climate hazard | Vulnerability description |
|---|---|
| **Extreme heat** | **The Urban Planning Sector** is highly vulnerable to residents, workers and visitors / tourists who use the green infrastructure and public works within the thermal islands in the lower parts of the city. Specific vulnerability in densely and intensively built-up neighborhoods with a large share of sealed surfaces, in combination with slopes and facades with leading southwestern exposure, lack of green and blue elements, as well as individual objects on the top floors of buildings with flat roofs made of heat-absorbing materials. Further increase vulnerability in low-income neighborhoods with unfavourable health status of the population<br>**The Tourism sector** is highly vulnerable to long periods of high outdoor temperatures: increasing cooling needs during the summer season; causing health problems for tourists in the middle of the summer season - heat and sunstroke, high blood pressure, etc .; deteriorating the condition of the snow cover and the conditions for skiing on Vitosha during the winter season<br>**The Human Health sector** is highly vulnerable to long periods of high daytime temperatures in combination with the so-called "Tropical nights". The most significant risks are associated with an increase in the number of fatal heat strokes |
| **Extreme cold** | **The Urban Planning Sector** is highly vulnerable to cases of extreme cold due to the presence of heavily built-up neighborhoods with a concentration of energy-poor residents.<br>**The human health sector** is highly vulnerable to prolonged periods of low ambient temperatures, increasing the risk of cardiovascular events, colds, frostbite (sometimes fatal). |
| **Heavy rains** | **The Urban Planning sector** is highly vulnerable to consumers and assets located in low and flat places near slopes and areas with large catchments and limited capacity of rainwater containers. Also important for the level of vulnerability are the fragmented implementation of measures for river correction and drainage without retaining and neutralizing volumes in certain parts of the currents. |
| **Intense rainfall** | **The Water Sector** is highly vulnerable to heavy rainfall due to the likelihood of exceeding the hydraulic capacity of sewers and the occurrence of short-term, local floods, mainly affecting the street infrastructure and ground floors of buildings.<br>**The Urban Planning sector** is highly vulnerable to consumers and assets located in low and flat places near slopes and areas with large catchments and limited capacity of rainwater containers. Poorly developed neighborhoods are also particularly vulnerable. Also important for the level of vulnerability are the fragmented implementation of measures for river correction and drainage without retaining and neutralizing volumes in certain parts of the currents.<br>**The Transport sector** is highly vulnerable to heavy rainfall, which can cause damage to the underground transport infrastructure of the metro and subways and lead to interruptions and delays in public transport. Disturbances in the power supply of traffic control systems, tram, trolleybus and metro are also possible.<br>**The Tourism sector** is highly vulnerable to heavy rainfall, leading to deteriorating conditions for all kinds of outdoor recreational activities; the need for higher insurance costs<br>**The Human Health Sector** is highly vulnerable to heavy rainfall, which leads to flooding of the low and underground levels of buildings located in the lower parts of the city and along rivers and pollution of water sources. There is a risk of injuries, infectious diseases, allergies and dermatitis in floods and landslides |
| **Reduction of snowfall** | **Sector Tourism** is highly vulnerable to shortening the period suitable for skiing on Vitosha, due to lack of snow and water for the production of artificial snow, but without much effect on tourism activities in the city. |
| **Storm** | **The Forestry and Agriculture sector** is highly vulnerable to intense storms, with moderate to significant consequences of damage to groups of trees or entire forests, potentially significant damage to trees in urban environments, damage to crops, erosion of unforested steep slopes.<br>**The Human health sector** is highly vulnerable to intense storms with very strong winds, accompanied by rain and thunder, which can lead to injuries and deaths from lightning, flying objects or fallen trees and branches due to strong winds, meteotropic reactions and so on. |

| Climate hazard | Vulnerability description |
|---|---|
| **Strong wind** | **The Urban Planning Sector** is highly vulnerable to groups with specific diseases |
| **Drought** | **The forestry and agriculture sector** is highly vulnerable, with significant damage from stress and damage to crops, forests and farm animals. In the case of forests, successive years with droughts can be particularly unfavorable, which can lead to significant deterioration in health and high mortality. Possible significant damage in case of forest fires<br>**The Tourism sector** is highly vulnerable to drought due to: lack of water, which makes it impossible to produce artificial snow on Vitosha; lack of water and food for the needs of tourists and related diseases; increased risk of fires |
| **Fog** | **The Human health sector** is highly vulnerable to the formation of fogs, which in combination with polluted air (so-called smog) have a negative impact on the health of those suffering from respiratory problems. Cases of fog are also associated with an increase in the number of accidents and traffic injuries<br>**The Tourism sector** is highly vulnerable to fog due to: deterioration of the conditions for staying and conducting recreational activities outdoors; difficult transport access to Sofia and to tourist sites in the municipality due to reduced visibility; Health problems for tourists due to deteriorating air quality. |
| **Contrasting changes of time** | **The Urban Planning Sector** is highly vulnerable to users of the public urban environment and to some critical public services related to mobility and stay - public spaces, intermodal transport hubs at peak traffic loads and disruptions in the normal functioning of infrastructure due to severe weather conditions and behavioral changes. Particularly vulnerable are groups with deteriorating health.<br>**The Tourism Sector** is highly vulnerable to the presence of fogs due to health problems among tourists; this hazard also sets prerequisites for avalanches on Vitosha in winter.<br>**The Human health sector** is highly vulnerable to day-to-day contrast changes associated with frequent meteotropic reactions. |
| **Decreased bioclimatic comfort** | **The Urban Planning Sector** is highly vulnerable to dwellers and users of living spaces with an imbalance between sun exposure and shading; causes subtle but lasting effects on health and behavior, as well as stress on heating and cooling systems; for groups with limited access to such systems due to energy poverty, lasting health effects and disability can be expected<br>**The Tourism Sector** is highly vulnerable to declining bioclimatic comfort, which may lead to a decline in interest in Sofia as a tourist destination.<br>**The Human Health Sector** is highly vulnerable to the manifestation of unfavorable weather for human bioclimatic comfort, which limits stays and outdoor activities and poses a risk to health. |

*Таблица 23. High ecological vulnerability of Sofia Municipality to climate risks*

| Climate hazard | Vulnerability description |
|---|---|
| **Extreme heat** | **The Environment and Biodiversity sector** is highly vulnerable to extreme heat due to the likelihood of overheating damage and functional disturbances in ecosystems, combined with higher water consumption in urban areas. The unfavorable abiotic environment in cities creates a high demand for ecosystem services at a time when ecosystems are at a disadvantage for their provision |
| **Intense rainfall** | **The Waste Sector** is highly vulnerable to heavy rainfall due to the likelihood of an increase in landfill leachate and a decrease in the efficiency of water treatment stations in local landfills. |
| **Storm** | **The Forestry and Agriculture sector** is highly vulnerable to intense storms, with moderate to significant consequences of damage to groups of trees or entire forests, potentially significant damage to trees in urban environments, damage to crops, erosion of unforested steep slopes.<br>**The Environment and Biodiversity sector** is highly vulnerable to storms, mainly in forest and urban ecosystems, with possible lasting damage despite relatively short exposure. |

| Climate hazard | Vulnerability description |
|---|---|
| **Drought** | **The forestry and agriculture sector** is highly vulnerable, with significant damage from stress and damage to crops, forests and farm animals. In the case of forests, successive years with droughts can be particularly unfavorable, which can lead to significant deterioration in health and high mortality. Possible significant damage in case of forest fires.<br>**The Environment and Biodiversity Sector** is highly vulnerable to droughts in highly modified ecosystems (urban, agro-ecosystems), as well as to wetlands, low-water rivers and lakes. Sensitivity is particularly high due to the high concentration of the population, whose consumption increases the demand for ecosystem services in times of ecosystem stress. |
| **Contrasting changes of time** | **The Environment and Biodiversity Sector** is highly vulnerable to contrasting changes over time, which are particularly detrimental to the long-term development of ecosystems, as a factor in potential biodiversity loss, especially from highly specialized and endemic or pollination-dependent species in pollination-dependent symbiosis or with specific nutritional interactions |

### 5.1.2. Most significant climate risks

The sectoral analyzes show a total of 33 climate risks with a high level of impact related to a total of 13 of the climate hazards identified according to the Sofia Municipality's exposure assessment. The highest level of risk, with a maximum score of 9 after the application of formula (3), described in the methodological section of the report, was identified in a total of 11 cases in the studied sectors. The highest climate risks are identified in the Human Health sector - a total of 7, with 4 of them assigned a maximum rating. Of the climatic hazards, extreme heat leads to high risk in most sectors - a total of 6, and for 3 of them the assessment is maximum. The least high climate risks are identified for the Building sector - only one with a score of 6, to storms.

A summary of the high climate risks for Sofia Municipality is presented in *Table 24.*

*Table 24. Summary of the high climatic risks for Sofia Municipality*

| Climate hazadr | Degree of exposure | Water | Forestry and agriculture | Urban planning | Environment and biodiversity | Waste | Buildings | Transport | Tourism | Human health |
|---|---|---|---|---|---|---|---|---|---|---|
| Extreme heat | 3 | | 6 | 9 | 9 | | | 6 | 6 | 9 |
| Extreme cold | 2 | | | | | | | | | 9 |
| Temperature changes | 2 | | | | | | | | | |
| Heavy rains | 2 | | | 6 | | | | | | |
| Intense rainfall | 3 | 6 | | 9 | | 6 | | 6 | | 6 |

| Climate hazadr | Degree of exposure | Water | Forestry and agriculture | Urban planning | Environment and biodiversity | Waste | Buildings | Transport | Tourism | Human health |
|---|---|---|---|---|---|---|---|---|---|---|
| Changes in precipitation amount | 1 | | | | | | | | 6 | |
| Reductions in snowfall | 2 | | | | | | | | 9 | |
| Floods | 1 | 6 | | | | 6 | | 6 | | |
| Drought | 2 | 6 | 9 | | 9 | | | | | |
| Storm | 3 | | 9 | | 6 | | 6 | | | 6 |
| Hail | 2 | | | | | | | | | |
| Strong wind | 2 | | | | | | | | | |
| Fog | 3 | | | | | | | | | 6 |
| Contrasting changes of weather | 3 | | | 6 | 9 | | | | | 9 |
| Decreased of the bioclimatic comfort | 3 | | | 6 | | | | | | 9 |
| Landslides | 1 | | | | | | | 6 | | |
| Fires (due to natural causes) | 2 | | 6 | | | | | | | |

Table 25 ranks the high climate risks for Sofia Municipality according to the numerical value of the assessment, showing for each risk the climate hazard that is the root cause, the vulnerable sector and a description of the potential negative impact.

*Table 25. Classification and description of high climatic risks for Sofia Municipality*

| Climatic danger | Sector | Rate of climatic risk | Description of the impact |
|---|---|---|---|
| **Extreme heat** | **Urban planning** | **9** | Mortality, disease, disability due to extreme heat and related phenomena; overheating deformations; overheating drying |
| | **Environment and biodiversity** | **9** | Reduction of net productivity, and hence water and biomass yields - food, wood, fiber, meat and products from wild and domestic animals and plants. In the long run, it is possible to adapt ecosystems, accompanied by changes in species composition<br>Increased demand and potentially lower supply of regulatory ecosystem services, especially critical within the ecological red lines for the heat island |

| Climatic danger | Sector | Rate of climatic risk | Description of the impact |
|---|---|---|---|
| | **Human health** | 9 | Deterioration of temperature comfort, danger of overheating of the body, which can lead to rash, syncope, cramps, exhaustion and heat stroke |
| **Extreme cold** | **Human health** | 9 | Deterioration of temperature comfort, risk of cardiovascular accidents, colds, frostbite (sometimes fatal) |
| **Intense rainfall** | **Urban planning** | 9 | Mortality, injuries, diseases from heavy rains and related phenomena; destruction, flood damage |
| **Reductions in snowfall** | **Tourism** | 9 | Shortening the ski season on Vitosha |
| **Storm** | **Forestry and agriculture** | 9 | Damage to groups of trees or entire forests, potentially significant damage to trees in urban areas, damage to crops, erosion of unforested steep slopes. With very strong winds, windthrows are possible in forests with potentially significant environmental and economic consequences |
| **Drought** | **Forestry and agriculture** | 9 | Damage from stress and damage to crops, forests and farm animals |
| | **Environment and biodiversity** | 9 | Reduction of net productivity, and hence water and biomass yields - food, wood, fiber, meat and products from wild and domestic animals and plants. In the long run, it is possible to adapt ecosystems, accompanied by changes in species composition<br>Increased demand and potentially lower supply of regulatory ecosystem services, especially critical within the ecological red lines for the heat island |
| **Decreased of the bioclimatic comfort** | **Human health** | 9 | Restriction of stay and outdoor activities, increase in the number of cardiovascular accidents. |
| **Contrasting changes of time** | **Environment and biodiversity** | 9 | Change and imbalance of life cycles of species due to temperature stress; disruption of their functional interactions.<br>As a result, phenology-dependent ecosystem services, such as pollination and therefore agricultural production, may be lost.<br>In the long run, it is possible for populations of highly specialized species (including endemics) to decrease or disappear, increasing the climatic vulnerability of ecosystems, accompanied by changes in their species composition. |
| | **Human health** | 9 | Meteotropic reactions, increase in the number of cardiovascular accidents. |
| **Extreme heat** | **Forestry and agriculture** | 6 | Starting and spreading fires, heat stress and damage to crops and woody plants. |
| | **Tourism** | 6 | Decrease in tourist demand in the middle of the summer season and decrease in demand for ski tourism in winter. Increase energy consumption for cooling |
| | **Transport** | 6 | Damage to the road surface and increased risk of accidents and incidents. Deformation of the railroad. Increasing passenger discomfort in public transport. Increased need for cooling of personal cars with air conditioners, which leads to higher than normal fuel consumption and correspondingly higher emission values |

| Climatic danger | Sector | Rate of climatic risk | Description of the impact |
|---|---|---|---|
| **Changes in precipitation** | **Tourism** | **6** | Shortening the winter season; water shortage |
| **Heavy rains** | **Urban planning** | **6** | Mortality, trauma, diseases from torrential rains and related phenomena; destruction, flood damage. |
| **Intense rainfall** | **Water** | **6** | Floods in third party properties and / or damage to urban infrastructure caused by insufficient sewerage capacity. |
| **Intense rainfall** | **Waste** | **6** | Significant increase of the infiltrate from the landfills, compromising the work of the local wastewater treatment plants of the landfills and pollution of soils, waters and water bodies. |
| | **Transport** | **6** | Damages to the transport infrastructure - ground and underground. Violations in the power supply of the city transport network - traffic lights, power supply of trams and trolleybuses, subway. Risk of interruption of access due to flooded transport infrastructure. Possible interruptions and delays in public transport |
| | **Human health** | **6** | Danger of injuries, infectious diseases, allergies and dermatitis from floods and landslides |
| **Fires (due to natural causes)** | **Forestry and agriculture** | **6** | Direct destruction of ecosystems, incl. those of high natural value and habitats of rare species.<br>Functional disorders leading to facilitated entry of diseases, pests and invasive species<br>The level of negative impact on ecosystem services is likely to be most pronounced in the permanent reduction of services provided by affected forests, namely water collection and filtration, recreation, forest material services such as mushroom and herb extraction and others. |
| **Floods** | **Water** | **6** | Impossibility for safe drainage of wastewater |
| | **Waste** | **6** | Flooding of landfill cells, internal roads and drainage infrastructure of the landfill, incl. removal of waste outside the boundaries of the landfill and environmental pollution |
| | **Transport** | **6** | Damages to the transport infrastructure - ground and underground. Interruption of access due to flooded transport infrastructure. Possible interruptions and delays in public transport |
| **Drought** | **Water** | **6** | Interruption / reduction of water supply due to water shortage |
| **Storm** | **Buildings** | **6** | Damage to poorly fortified buildings and parts of buildings due to very strong winds accompanied by rain and thunder and falling trees and branches on buildings |
| | **Environment and biodiversity** | **6** | Negative impact on the integrity and sustainability of ecosystems, and hence on the provision of material services, incl. the most important for adaptation - water<br>Increased need for windshields along roads and other infrastructure and in wide fields, which also serve as islands of biodiversity |
| | **Human health** | **6** | Injuries and deaths from lightning, flying objects or fallen trees and branches due to strong winds, meteotropical reactions, etc. |

| Climatic danger | Sector | Rate of climatic risk | Description of the impact |
|---|---|---|---|
| **Contrasting changes over time** | **Urban planning** | **6** | Mortality and diseases caused by contrasting changes of time |
| **Decreased of the bioclimatic comfort** | **Urban planning** | **6** | Diseases and drying of vegetation caused by bioclimatic discomfort |
| **Fog** | **Human health** | **6** | Exacerbation of respiratory problems, increase in the number of traffic accidents and traffic injuries |
| **Landslides** | **Transport** | **6** | Interruption of access from / to remote areas due to damaged road infrastructure. Damage to transport infrastructure |

### 5.1.3. Vulnerability and impact indicators

All indicators for the defined climate hazards are presented in Table 9, in Section 2 of the document. In the sector analyzes, indicators for monitoring of all identified vulnerabilities with a degree of at least "moderate" and assessment of 3 are prepared. All these indicators are presented in Annex 2. In Table 26, the indicators for monitoring of the high-level vulnerabilities summarized in section 5.1.1 are presented.

*Table 26. Summary of indicators for monitoring high-vulnerability*

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| **Extreme heat** | **Urban planning** | The current population (Sofia Municipality / city of Sofia / settlements / urban planning units) compared to forecasts for 2030, living or using an urban environment located within heat islands<br><br>Population density / Sofia / Bankya / Novi Iskar / Buhovo / settlements / urban units (compared to the national / regional average) compared to forecasts for 2030, living or using urban environment located within heat islands<br><br>Residential / service / production / recreational, etc. territories located within heat islands | Number<br>%<br><br>Residents or Users / ha<br>%<br><br>Area<br>% |
| | **Environment and biodiversity** | • Reducing the area of ecosystems (Difference between the spatial coverage of ecosystems in the baseline (mapping in 2017 outside NATURA 2000, and Corine Landcover 2018 for NATURA 2000) and the new values determined by monitoring the same ecosystems<br>• Deterioration of ecosystems: the difference between the state of ecosystems in the baseline and the new values determined by monitoring the same ecosystems<br>• Reduction of the populations of protected species (according to the reporting on NATURA | ha<br><br>Number of units on the rating scale for the respective ecosystem<br><br>Number of identified individuals |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | 2000 and the monitoring within the framework of the Vision for Sofia) | |
| | **Tourism** | • Number of days with heat waves<br>• Number of heat waves | No. / year.<br>No. / year |
| | **Transport** | Share of projects for construction of transport infrastructure in which there is an analysis of the impact on the environment, taking into account the needs related to adaptation to climate change and mitigation of its consequences and disaster resilience. | % |
| | **Human health** | • Number of days with heat waves<br>• Number of heat waves | No. / year<br>No. / year |
| **Extreme cold** | **Human health** | • Number of days with cold waves<br>• Number of cold waves | No. / year<br>No. / year |
| **Heavy rains** | **Urban planning** | Residential / service / production / recreational, etc. areas falling within the scope of flooded areas from heavy or intense rainfall | Area |
| **Intense rainfall** | **Води** | Number of local floods due to exceeded sewerage capacity | Number of short-term floods / year |
| | **Urban planning** | Residential / service / production / recreational, etc. areas falling within the scope of flooded areas from heavy or intense rainfall | Area |
| | **Waste** | Number of cases of rains that caused the closure of the wastewater treatment plants at the landfills | Number |
| | **Buildings** | Number of cases of rain that caused flooding of low levels of buildings | No. / year |
| | **Transport** | Number of cases of heavy and intense rainfall that caused flooding of metro stations and/or subways | No. / year |
| | **Tourism** | Annual number of days with rainfall over 30 l/(s.ha) | No. / year |
| | **Human health** | • Annual number of days with precipitation over 25 mm<br>• Annual number of days with precipitation with intensity over 0.18 mm / min | No. / year |
| **Reduction of snowfall** | **Tourism** | Annual number of days with snowfall | No. / year |
| **Storm** | **Forestry and agriculture** | Number of storms that can cause significant damage to woody plants | % of cases of storms with values ≥90th percentile compared to the number of all cases in the studied climate series |
| | **Urban planning** | The current population (Sofia Municipality / city of Sofia / settlements / urban units) compared to forecasts for 2030, living or using an urban environment falling within the scope of storms or strong winds<br>Population density / Sofia / Bankya / Novi Iskar / Buhovo / settlements / urban units (compared to the national / regional average) compared to | Number<br>%<br><br>Residents or Users /ha |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | forecasts for 2030, living or using urban environment in the range of storms or strong winds<br>Residential / service / production / recreational, etc. areas covered by storms or strong winds | Area |
| | **Environment and biodiversity** | • Reducing the area of ecosystems (Difference between the spatial coverage of ecosystems in the baseline (mapping in 2017 outside NATURA 2000, and Corine Landcover 2018 for NATURA 2000) and the new values determined by monitoring the same ecosystems<br>• Deterioration of ecosystems: the difference between the state of ecosystems in the baseline and the new values determined by monitoring the same ecosystems<br>• Reduction of the populations of protected species (according to the reporting on NATURA 2000 and the monitoring within the framework of the Vision for Sofia) | ha<br>Number of units on the rating scale for the respective ecosystem<br>Number of identified individuals |
| | **Buildings** | • Number of cases of rain that caused flooding of low levels of buildings<br>• Number of cases of strong winds causing damage to buildings | No. / year<br>No. / year |
| | **Human health** | Annual number of days with storms | No. / year |
| **Strong wind** | **Urban planning** | The current population (Sofia Municipality /city of Sofia / settlements / urban units) compared to forecasts for 2030, living or using an urban environment falling within the scope of storms or strong winds<br>Population density / Sofia / Bankya / Novi Iskar / Buhovo / settlements / urban units (compared to the national / regional average) compared to forecasts for 2030, living or using urban environment in the range of storms or strong winds<br>Residential / service / production / recreational, etc. areas in the range of storms or strong winds | Number<br>%<br>Residents or Users /ha<br>Area |
| **Drought** | **Forestry and agriculture** | Periods without precipitation lasting at least ≥10 days | Frequency:<br>Number of non-rainy periods lasting ≥10 days for the April-October interval, for a multi-year period<br>For intensity:<br>Relative share (%) of no-rain periods with a duration of> 21 days, compared to all cases of drought periods |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | | (≥10 consecutive days) |
| | **Environment and biodiversity** | • Reducing the area of ecosystems (Difference between the spatial coverage of ecosystems in the baseline (mapping from 2017 outside NATURA 2000, and Corine Landcover 2018 for NATURA 2000) and the new values determined by monitoring the same ecosystems<br>• Deterioration of ecosystems: the difference between the state of ecosystems in the baseline and the new values determined by monitoring the same ecosystems<br>• Reduction of the populations of protected species (according to the reporting on NATURA 2000 and the monitoring within the framework of the Vision for Sofia) | ha<br>Number of units on the rating scale for the respective ecosystem<br>Number of identified individuals |
| | **Tourism** | Annual number of periods without precipitation lasting > 21 days | No. / year |
| **Fog** | **Tourism** | Annual number of days with fog | No. / year |
| | **Human health** | Annual number of days with fog | No. / year |
| **Contrasting changes over time** | **Urban planning** | The current population (Sofia Municipality / city of Sofia / settlements / urban units) compared to forecasts for 2030, living or using an urban environment falling within the scope of contrasting weather changes<br>Population density (Sofia municipality / Bankya city / Bankya city / Novi Iskar city / Buhovo city / settlements / urban planning units (compared to the national / regional average) compared to forecasts for 2030, living or using urban environment in the range of areas with contrasting changes of time | Number<br>%<br>Residents or users /ha |
| | **Environment and biodiversity** | • Reducing the area of ecosystems (Difference between the spatial coverage of ecosystems in the baseline (mapping 2017 outside NATURA 2000 and Corine Landcover 2018 for NATURA 2000) and the new values determined by monitoring the same ecosystems<br>• Deterioration of ecosystems: the difference between the state of ecosystems in the baseline and the new values determined by monitoring the same ecosystems<br>• Reduction of the populations of protected species (according to the reporting on NATURA 2000 and the monitoring within the framework of the Vision for Sofia) | ha<br>Number of units on the rating scale for the respective ecosystem<br>Number of identified individuals |
| | **Tourism** | • Frequency of days with contrasting change of time<br>• Annual number of avalanches in Vitosha | %<br>No. / year |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | **Human health** | • Index of the frequency of contrasting time changes *Kn* (ratio in % between the number of contrasting time changes to the total number of days in a given month).<br>• Annual number of avalanches on Vitosha | %<br>No. / year |
| **Decreased of the bioclimatic comfort** | **Urban planning** | The current population (Sofia Municipality / city of Sofia / settlements / urban units) compared to forecasts for 2030, living or using an urban environment falling within the range of areas with low bioclimatic comfort<br>Population density (Sofia municipality / Bankya city / Bankya city / Novi Iskar city / Buhovo city / settlements / urban planning units (compared to the national / regional average) compared to forecasts for 2030, living or using urban environment in the range of areas with low bioclimatic comfort | Number<br>%<br>Residents or users listed in Annex 4 /ha |
| | **Tourism** | Frequency (%) of manifestations of weather without restrictions for prolonged stay outdoors | % |
| | **Human health** | Frequency (%) of manifestations of weather with restrictions for prolonged stay outdoors | % |

All impact indicators identified in the sector analyzes are presented in Annex 2 of the report. *Table 27* summarizes the indicators for monitoring the impacts associated with the highest climate risks described in *Table 24* above.

*Table 27. Summary of indicators for the impact of high climate risks*

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| **Extreme heat** | **Forestry and agriculture** | Areas affected by stress and damage to crop forests from extreme temperatures and forest fires<br>Number of trees damaged by stress and перисхед in settlements due to extreme temperatures | ha/per year<br>No. / year |
| | **Urban planning** | Percentage of inhabitants and users of (residential / public) buildings / spaces and green / blue / green areas affected by extreme heat, including: mortality, disease, disability; overheating deformations; overheating drying | % |
| | **Environment and biodiversity** | • Reducing the area of ecosystems (Difference between the spatial coverage of ecosystems in the baseline (mapping from 2017 outside NATURA 2000, and Corine Landcover 2018 for NATURA 2000) and the new values determined by monitoring the same ecosystems<br>• Deterioration of ecosystems: the difference between the state of ecosystems in the baseline and the new values determined by monitoring the same ecosystems<br>• Reduction of the populations of protected species (according to the reporting on NATURA | ha<br>Number of units on the rating scale for the respective ecosystem |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | 2000 and the monitoring within the framework of the Vision for Sofia) | Number of identified individuals |
| | **Tourism** | • Number of tourists - total and by months;<br>• Realized overnight stays - total and by months;<br>• Usage of the accommodation capacity on monthly basis (in %);<br>• Average stay of visitors on monthly basis (in days);<br>• Employment in tourism (in number and %);<br>• Revenues from tourism by months (in BGN);<br>• Number, capacity (beds) and structure of accommodation places and places for food and entertainment<br>• Energy consumption per night compared to the total energy consumption per capita per day (in kWh)<br>• Number (share) of tourism enterprises that take action to reduce energy consumption - insulation, windows, lighting, etc.<br>• Number (share) of tourism enterprises participating in climate change mitigation schemes, such as CO2 offsets, low energy systems, etc., as well as adaptation measures and actions<br>• Annual amount of energy used from renewable sources (MWh) by type of RES and share in total energy consumption (in %)<br>• Structure of the energy sources of the hotels - by types and quantities<br>• Number (share) of hotels using RES at building level<br>• Number (share) of the hotels with energy performance certificate and distribution along the energy classes (certificates for energy performance of hotels in Sofia Municipality) | Number of tourists (thousand)<br>Number of nights (thousand)<br>%<br>Number of days<br>%<br>BGN (milion)<br>Number beds (thousand)<br>kWh<br>%<br>%<br>MWh (%)<br>% (MWh) |
| | **Transport** | Number of registered cases of damage to transport infrastructure due to climate hazards.<br>Part of relevant transport infrastructure (street network, railroad, metro stations, subways, bridge facilities, traffic lights, contact cable network, etc.) damaged by extreme weather events. | No. / year<br>% |
| | **Human health** | • Increase in the total mortality above the expected (average for the respective period) level during the periods with heat waves and up to three days after their passing (due to the so-called delayed impact).<br>• Number of emergency calls<br>• Number of accidents at work | %<br>No. / year<br>No. / year |
| **Extreme cold** | **Urban planning** | Percentage of inhabitants and users of (residential / public) buildings / spaces and green / blue / | % |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | green areas affected by extreme cold, including: mortality, disease, trauma; deformations from cooling; drying from cooling | |
| | **Human health** | • Increase in overall mortality above average during periods of cold waves and up to three days after their passage.<br>• Number of emergency calls | % |
| **Heavy rains** | **Urban planning** | Percentage of inhabitants and users of (residential / industrial / recreational / service) buildings / spaces, technical facilities and elements of public works, green / blue / green areas affected by heavy rains, including: mortality, injuries, diseases; destruction, damage | % |
| **Intense rainfall** | **Water** | Number of complaints about flooded properties | No./10000 users |
| | **Urban planning** | Percentage of inhabitants and users of (residential / industrial / recreational / service) buildings / spaces, technical facilities and elements of public works, green / blue / green areas affected by heavy rains, including: mortality, injuries, diseases; destruction, damage | % |
| | **Waste** | Increase in the values of the controlled parameters of the wastewater treatment plants, evident from the Diary for documenting the results of the monitoring and the Diary for elimination of emergency situations | % |
| | **Transport** | Number of registered cases of damage to transport infrastructure due to climatic hazards<br>Part of relevant transport infrastructure (street network, railroad, metro stations, subways, bridge facilities, traffic lights, contact cable network, etc.) damaged by extreme weather events.<br>Number of interruptions in the power supply of the urban transport network, which led to the interruption of public transport services.<br>Statistics on road accidents due to climate risks. | No. / year<br>%<br>No. / year<br>Number |
| | **Human health** | | |
| **Changes in precipitation** | **Tourism** | • Number of tourists - total and by months<br>• Realized overnight stays - total and by months<br>• Occupancy of the accommodation capacity by months (in %)<br>• Average stay of visitors by months (in days)<br>• Employment in tourism (number and %)<br>• Revenues from tourism by months (in BGN)<br>• Number, capacity (beds) and structure of accommodation places and places for food and entertainment | Number of tourists (thousand)<br>Number of nights (thousand)<br>%<br>Number of days<br>%<br>BGN (milion)<br>Number of beds (thousand) |
| **Reduction of snowfall** | **Tourism** | • Number of tourists - total and by months | Number of tourists (thousand) |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | | • Realized overnight stays - total and by months;<br>• Occupancy of the accommodation capacity by months (in%)<br>• Average stay of visitors by months (in days)<br>• Employment in tourism (number and %)<br>• Revenues from tourism by months (in BGN)<br>• Number, capacity (beds) and structure of accommodation places and places for food and entertainment | Number of nights (thousand)<br>%<br>Number days<br>%<br>BGN (milion)<br>No beds (thousand) |
| **Floods** | **Water** | Days with flooded sewerage infrastructure | No. days/yearly |
| | **Waste** | Temporary suspension of the landfill due to flood, registered in the Landfill Diary and Emergency Response Log | Number |
| | **Transport** | Number of registered cases of closed streets / road sections due to damage to the transport infrastructure due to landslides or floods. | No. / year |
| **Storm** | **Forestry and agriculture** | Number of damaged trees from heavy rainfall and hail | No. / year |
| | **Environment and biodiversity** | | |
| | **Buildings** | Annual increase in registered cases of damage to buildings after storms and strong winds | % |
| | **Human health** | Number of victims / deaths in extreme weather - storms, hail, strong winds, etc. | No. / year |
| **Drought** | **Water** | Number of population affected and duration of water supply interruptions due to water shortages | Ratio * |
| | **Forestry and agriculture** | • Affected area with stress and damage to crops and farm animals<br>• Affected area with stress and forest damage due to droughts<br>• Number of damaged trees in settlements due to droughts<br>• Area of affected forests during droughts | ha/year<br>ha/year<br>No. /year<br>ha/year |
| | **Environment and biodiversity** | | |
| **Fog** | **Human health** | • Deaths due to diseases of the respiratory system<br>• Hospitalized cases (discharged and death cases) in the hospitals of medical institutions with diseases of the respiratory system | Number of deaths yearly per 100 thousand people<br>Number of cases yearly per 100 thousand people |
| **Contrasting changes over time** | **Urban planning** | Percentage of occupants and users of (residential / public) buildings / spaces and green / blue / green areas affected by contrasting weather changes, including: mortality and diseases caused by contrasting weather changes | % |

| Climatic danger | Sector | Vulnerability indicator | Unit |
|---|---|---|---|
| | **Environment and biodiversity** | | |
| | **Human health** | • Number of accidents at work<br>• Number of tourists injured in avalanches on Vitosha | No. / year<br>No. / year |
| **Decreased of the bioclimatic comfort** | **Urban planning** | Percentage of occupants and users of (residential / public) buildings / spaces and green / blue / green areas affected by bioclimatic discomfort, including: diseases and drying of vegetation caused by bioclimatic discomfort | % |
| | **Human health** | | |
| **Fires due to natural causes** | **Forestry and agriculture** | Area of affected forests | ha//yearly |
| **Landslides** | **Transport** | Number of registered cases of closed streets / road sections due to damage to the transport infrastructure due to landslides or floods | No. / year |

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