Climate Change Impact and Vulnerability Analysis in the City of Bratislava: Application and Lessons Learned

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Abstract

Consequences of climate change, like more frequent extreme weather events, are major challenges for urban areas. With diverse approaches for adaptation strategy development available to cities, comparability with respect to risks, vulnerabilities, and adaptation options is limited. The lack of standardized methods and approaches to prioritize and select appropriate adaptation options restricts the exchange of best practices between cities.

This paper presents the application of a vulnerability analysis for the city of Bratislava, Slovakia. It describes how the approach was employed to analyze the effects extreme precipitation has on the road network and reports on how different stakeholders were involved in the process, how relevant data was employed for the assessment, and which results were produced. Based on this process description, typical problems, resulting method adaptations, and lessons learned are described.

Keywords: Risk Analysis, Vulnerability Assessment, Climate Change, Critical Infrastructure Protection, Climate Change Adaptation.

1 Introduction

Climate models project robust differences in regional climate characteristics between the present-day state and global warming scenarios with average temperature increases of 1.5°C and 1.5°C to 2°C. These differences include significant increases in mean temperature in most land and ocean regions (high confidence), hot extremes in most inhabited regions (high confidence), heavy precipitation in several regions (medium confidence), and the probability of drought and precipitation deficits in some regions (medium confidence). [1] Urban population centers and their critical infrastructure components are increasingly vulnerable to extreme events related to these changing climate characteristics [2], especially fluvial and pluvial flooding, flash floods caused by heavy precipitation, temperature extremes, as well as thunderstorms and other heavy storms [3]. This is also true for the City of Bratislava, capital of Slovakia and home of approx. 430,000 residents, that already suffers from a temperature increase of 2°C since 1951 and an increase of total annual precipitation amounts. The storms that hit the city today bring as much as 10% more precipitation compared to average records from the previous century. Heatwaves and droughts have been appearing with increased frequency and severity in the last three decades [4].

With an even higher degree of extreme weather events to be expected, Bratislava decided to take part in the EU-H2020 project "RESIN – Climate Resilient Cities and Infrastructures" [5]. RESIN was a research project investigating climate resilience in European cities. Through co-creation and knowledge brokerage between city decision-makers and researchers, the project developed tools to support decision-makers in designing and implementing climate adaptation strategies for their local contexts. Specifically, Bratislava decided to apply "IVAVIA – Impact and Vulnerability Analysis of Vital Infrastructures and Built-up Areas", a standardized process for the assessment of climate change-related risks and vulnerabilities in cities and urban environments that was developed as part of RESIN.

This paper describes the process and key findings of the Bratislava city case. The IVAVIA process was applied over the course of 18 months, contributing key elements to the "Climate Change Impact Atlas of Bratislava" [4].

The paper continues with introducing the background of risk-based vulnerability analysis and a brief description of the IVAVIA process (Section 2). It then presents an in-depth description of the application of IVAVIA to assess the risk pluvial flooding, a major threat for the City of Bratislava, poses to its road infrastructure (Section 3), and concludes with a short summary of the lessons learned and an outlook on further research steps (Section 4).

2 Background

2.1 State of the Art: Impact and Vulnerability analysis

Several methods and tools for risk analysis exist, with the "Words into Action Guidelines for National Disaster Risk Assessment" from the United Nations Office for Disaster Risk Reduction giving a comprehensive overview for the most frequently employed approaches [6].

On behalf of the German Federal Ministry for Economic Cooperation and Development, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), together with Adelphi and EURAC, developed the Vulnerability Sourcebook [7] in 2014, based on the Fourth Assessment Report of the IPCC. In 2017, the same authors provided a Risk Supplement [8] to the Vulnerability Sourcebook, based on the changes promoted in the Fifth Assessment Report [9] to provide guidance for indicator-based vulnerability and risk assessments. In this method, the usually massive amount of information and data about hazards, exposure, vulnerability, and other risk components is simplified by aggregating it to index scores (i.e. a number out of a full score), which are subsequently combined (e.g. using weighted arithmetic/geometric mean) to present risk levels as a single score.

In contrast, the German Federal Office of Civil Protection and Disaster Assistance (BBK) employs a multi-criteria impact and likelihood analysis based on risk matrices, an instrument also promoted as an ISO standard [10]. In this approach, impacts and probabilities of hazard scenarios are estimated (e.g. based on historical data or simulation models) and classified by defining threshold values for the different impact/probability classes, i.e. in which value range do potential impacts/probabilities have to lie to be classified in a certain way. Typically, risk matrices have four to seven impact classes and a similar number of probability classes. For any combination of impact and probability, a risk level or class (BBK: very high, high, intermediate, low) is determined. Both determining the thresholds and assigning risk levels requires political decisions that have to be taken with extreme care: It requires deciding when a certain number of fatalities is regarded as 'moderate' or 'significant' and which risk level requires which type of reaction, or, more simply put, which risk level is acceptable and which is not.

If no (or not enough) information or means for carrying out an indicator-based multi-criteria analysis is available, expert elicitation approaches might be employed. Here, individuals with a good understanding of the various components of disaster risk components of the area under study conduct a qualitative analysis using their expert judgements. The "Risk Systemicity Questionnaire" developed during the "Smart Mature Resilience project – SMR" [11] and the "UNISDR Disaster Resilience Scorecard for Cities" [12] are recently developed expert elicitation approaches. Both employ spreadsheet- and/or web-based questionnaires to elicit knowledge from experts and combine the gathered information into comprehensive overviews, e.g. by assigning scores to predefined answers and visualizing them using spider charts.

Other research projects investigated climate change-oriented resilience in European cities too: The project "Reconciling Adaptation, Mitigation and Sustainable Development for Cities – RAMSES" [13] developed methods and tools to quantify the impacts of climate change and the costs and benefits of adaptation measures to cities, while the project "Smart Mature Resilience – SMR" [14] aimed at developing a resilience management guideline to support city decision-makers in developing and implementing resilience measures.

The RESIN project developed practical and applicable methods and tools to support decision-makers in designing and implementing adaptation and mitigation strategies for their local contexts and in a participatory way. One of these methods is the risk-based vulnerability assessment methodology IVAVIA, which combines the indicator-based method from the original Vulnerability Sourcebook with the multi-criteria impact and likelihood analysis by the BBK.

2.2 IVAVIA: A Process for Impact and Vulnerability Analysis of Vital Infrastructures and Built-Up Areas

The IVAVIA process consists of seven modules in three stages: the qualitative stage, the quantitative stage, and the presentation of the outcome. Each module consists of three to six individual steps.

The modules and steps are described in detail in the IVAVIA Guideline document [15], with the more technical details of the process and reference information being covered by the IVAVIA Guideline Appendix. A more detailed explanation of the methodology with brief descriptions of example applications in Bilbao, Spain and Greater Manchester, UK can also be found in [16]. Here, only the key elements of IVAVIA will be introduced briefly.

The central element of the qualitative stage of IVAVIA are impact chains. They are cause-effect models describing the elements that contribute to the consequences a given hazard has on an exposed object (see **Fig. 1**). Each element of an impact chain is to be described in a qualitative way by specifying attributes[1]. Usually, impact chains are developed during collaborative workshops with domain experts. As a result, impact chains are not exhaustive, but describe the common understanding of these experts.

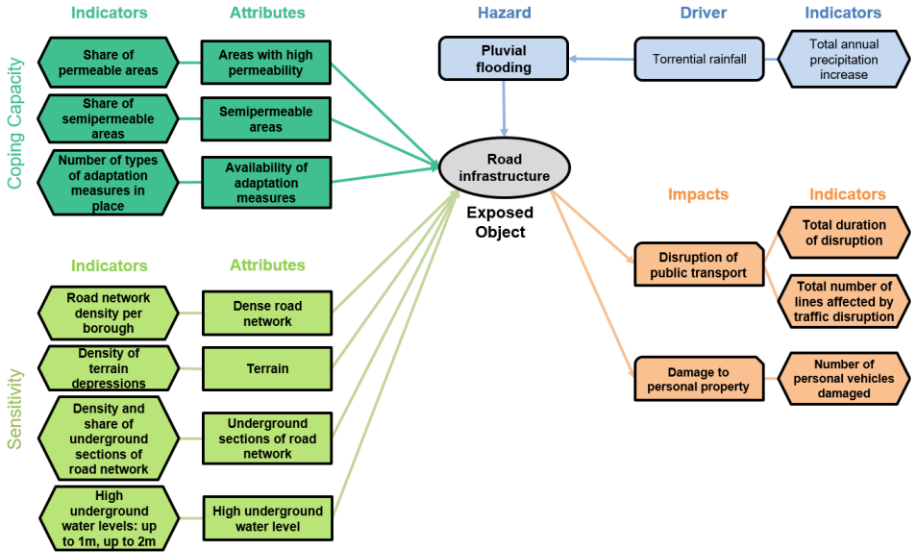

Fig. 1. Impact chain for the hazard-exposure combination "pluvial flooding on road infrastructure" in the city of Bratislava. Hazards and drivers in blue, exposed object in grey, coping capacity in green-blue, sensitivity in green, and impacts in orange. Rectangles: attributes; Hexagons: indicators.

For each attribute defined in an impact chain, measurable indicators need to be identified and associated data needs to be gathered. To ease the indicator selection process, established directories of standard indicators should be employed, for example, the annex of the Vulnerability Sourcebook ([7], p. 14-17) or the annex of the Covenant of Mayors for Climate and Energy Reporting Guidelines ([17], p. 61-67).

Communicating a multitude of complex, multi-dimensional indicators in a comprehensive way can be extremely complicated. Therefore, the calculated indicator values

[1] Attributes are inherent characteristics of the objects under analysis, such as sensitivity and coping capacity; they are the basis for determining indicators.

are normalized (e.g. via min-max normalization [18]), weighted, and aggregated (e.g. using weighted arithmetic mean [18]) to composite scores for different risk components.

Subsequently, risks are estimated. If sufficient historical data about impacts and occurrences of hazards for the definition of damage functions is available, these are used to estimate potential consequences, which are then classified using discrete, ordinal classes (e.g. “insignificant”, “minor”, or “disastrous” for impacts and “very unlikely”, “likely”, and “very likely” for probabilities). The resulting impacts and probability pairs, i.e. the risk scores, are then assigned to discrete, ordinal risk classes using a risk matrix.

If not sufficient historical data about past consequences and occurrences of hazards to derive damage functions is available, an alternative approach is to employ the available data to define aggregated hazard and exposure indicators as described in the Risk Supplement of the Vulnerability Sourcebook [8]. For example, data about flood depth and velocity can be combined to a single hazard indicator, while data about population density in flood-prone areas and exposed build-up area can be combined to an exposure indicator. These can then be combined with the composite risk components calculated to a single risk score.

3 Analyzing Risks and Vulnerabilities Regarding Climate Change for Bratislava

3.1 Situation in Bratislava

The City of Bratislava, capital of Slovakia, lies in the southern part of the country, which has suffered from a temperature increase of 1°C since 1988. Higher temperatures in warmer seasons have led to increased evapotranspiration, which results in occasional but heavy rainfall. However, southern Slovakia has suffered an almost 20% decrease in total annual precipitation and serious drought have been occurring almost every year since the 1990s [19]. A more complex analysis on intensity and length of warm and cool weather spells in the period 1951-2017 shows a continuous increase of above-normal temperature warm spells while below-normal cold temperature spells are continually decreasing [20].

Bratislava’s sectoral master plan on management of sewage water and rainwater sewage systems dates back to 2008 and is not suited anymore for the amount of urban development that occurred in the past 10 years, which resulted in an increase of impermeable land-cover. As a result, underpasses and whole street segments are often flooded after substantial rainfall, resulting in blockages and traffic jams.

To tackle these and other climate change-related issues, Bratislava committed itself to the Mayors Adapt initiative in 2014 and in the same year completed the EU Cities Adapt program with a climate change adaptation strategy. In 2017 an action plan to implement adaptation measures was developed. However, both the adaptation strategy and the action plan are based on a qualitative vulnerability assessment. Therefore, a new quantitative assessment applicable for spatial planning and permission procedures for development projects needed to be conducted.

3.2 Applying IVAVIA in the City of Bratislava

Following the IVAVIA process as described above, the assessment started with the identification of the most pressing climatic hazards for the city, i.e. heatwaves, droughts, and pluvial flooding, followed by a kick-off meeting with stakeholders from several departments of the municipality as well as external experts including health and environmental authorities, the Slovak Hydrometeorological institute, and other organizations operating in the area of health, sewage water management, and drinking water provision. The goals of this meeting were to introduce the participants to the methodology and design initial impact chains.

The initial workshop yielded three impact chains covering the effects of heatwaves and pluvial flooding on health and quality of life as well as droughts on green infrastructure. These were later on supplemented by two additional impact chains covering the effects of pluvial flooding on buildings and road infrastructure (see **Fig. 1**). During the initial workshop, the participants were not given explicit guidance on potential attributes, resulting in the identification and definition of more than 90 different potential attributes across all impact chains, mostly based on experience and knowledge of the participating stakeholders.

Therefore, the identified attributes underwent a thorough review to filter out unsuitable and duplicated attributes, re-categorize attributes to correct for misunderstandings (e.g. participants identified "low implementation of building-level adaptation measures for reducing the impacts of rainfall" as a sensitivity attribute), and reducing the number of attributes to a more manageable amount in order to facilitate result validation. Following this process, initial indicators for each attribute where defined and required data identified.

The subsequent months focused on data acquisition: For each indicator the available data, its spatial and temporal resolution, its data format, and the necessary licensing agreements were identified. This included data from the Slovak Statistical Office on borough level, published annually in the statistical yearbook, as well as data by the National Healthcare Information Centre of the Slovak Republic and the Slovak Hydrometeorological institute. In addition, Bratislava City and local research partner Comenius University in Bratislava processed their own data sources as well as open source data (e.g. from OpenStreetMap [21]) to calculate indicator maps. For example, a digital elevation model of Bratislava was used to identify existing and potential drainage basins and their outlets using hydrological and terrain modelling tools. This drainage basin model was then used to identify critical terrain depressions by vectorising the raster output and identifying the lowest sections of the drainage basins with depths up to 1 m. This information was subsequently used to calculate different indicators, e.g. "density of terrain depressions per borough" or "length of infrastructure exposed to terrain depressions". This method has also been used in [22], p. 73f. **Fig. 2.** shows part of the combined drainage basin and terrain depression model with identified critical sections of transport infrastructure and high-density terrain depression zones.

Other calculated indicators include pressure on the sewage system from the amount of surrounding impermeable area and estimated amount of water coming from impermeable areas into the combined sewage system, groundwater level depth, pressure on the sewage system based on population density in every borough and drinking water consumption in households, availability of different types of implemented adaptation measures, and share of (semi-)permeable areas.

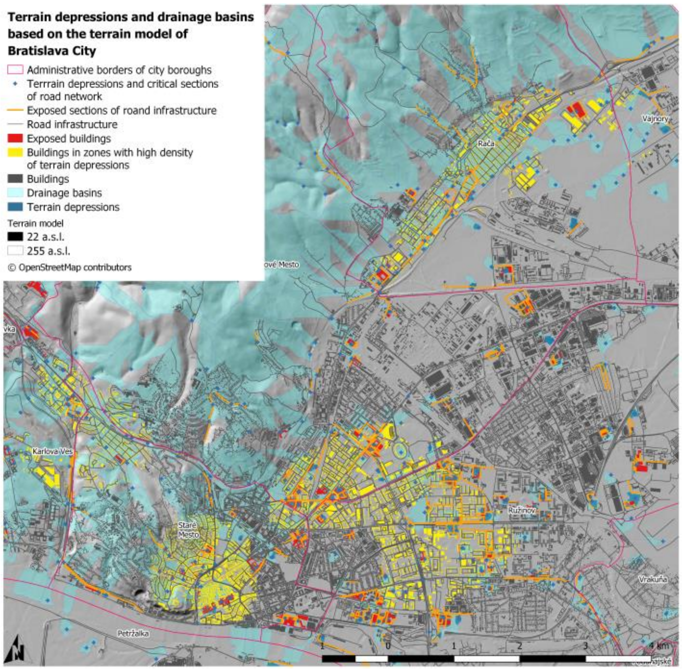

Fig. 2. Elevation model with analysis of drainage basins and terrain depressions, showing also zones of high density of terrain depressions (in yellow) – used for creating exposure indicators. Source: [4].

Single indicators were normalized using min-max normalization and combined to composite indicators for sensitivity, coping capacity, exposure, and hazard using weighted arithmetic mean. Initially, an expert judgment approach was to be employed for selecting indicator weights, reflecting the perceived importance of indicators. However, this process was judged as too subjective by the participants and subsequently, weights were chosen based on the results of a correlation analysis, allocating lower weights for indicators that were correlated to correct for statistical effects.

The resulting composite indicators were visualized as choropleth maps (see **Fig. 3** and **Fig. 4**) and validated by experts. Afterwards, the composite sensitivity and coping capacity indicators where combined to a vulnerability indicator (see **Fig. 5**, left), which in turn was combined together with the exposure and hazard indicator (see **Fig. 4**) to a final risk indicator (see **Fig. 5**, right). These results were in turn validated by local experts based on historic occurrences of flooding events.

3.3 Results

The assessment approach employed in Bratislava differs from the process description in section 2 in that risk are not estimated based on a multi-criteria impact and likelihood analysis but using an indicator-based approach as described in [8]. This is due to the limited amount of historical records about hazard occurrences and related impacts, which prohibits the definition of robust damage functions and the estimation of likelihoods. However, a non-probabilistic assessment for the present situation can be conducted with the indicator-based approach. In the future these results can easily be expanded to a probabilistic assessment.

The results of the assessment show for all impact chains that the city center located in the "Stare Mesto" (Old town) borough and the adjacent boroughs such as the more urbanized "Ružinov" and "Petržalka" usually yield the highest scores for vulnerability and risk (see **Fig. 5**). The more peripheral city boroughs have a rather rural character, with the majority of their area covered by permeable land-use or the Danube river running on their territory. These kinds of land use effectively mitigate the negative impacts of pluvial flooding, which is reflected in the assessment. The only exemption in this regard is the peripheral "Čunovo" borough. Although infrastructure density is relatively low here, the infrastructure that is located here is often affected by terrain depressions.

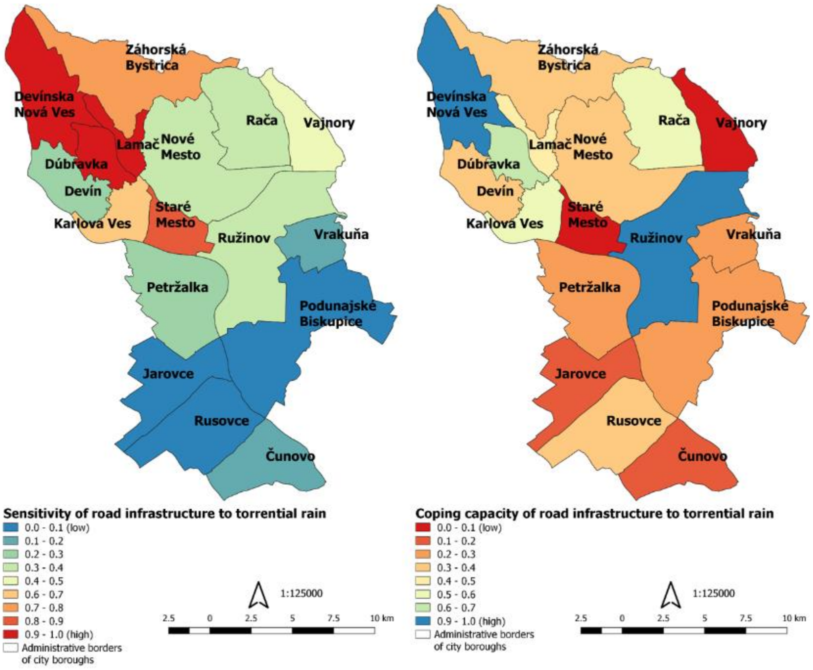

Fig. 3. Choropleth maps, left: Sensitivity of road infrastructure to torrential rain; right: Coping capacity of road infrastructure to torrential rain. Source: [4].

With regard to the morphology of the city area, several boroughs are strongly affected by the vicinity of the Male Karpaty (Small Carpathians) mountain range in the north and northwest. Although the vicinity of the mountains is an asset in mitigation of extreme heat, the terrain also creates natural drainage basins which accumulate precipitation and channel it into the lower and more urbanized sections of the boroughs at the foothills.

The results of the vulnerability assessment were compiled into an Atlas that has been created with the aim to provide useful information for city administration practitioners at all levels, local research institutions, as well as practitioners from private sector (such as architects, landscape architects, and development companies) and be also a supporting tool to decision-makers and policy makers across all scales – borough, city, regional, as well as government level. Besides more than 90 choropleth maps (displaying borough level assessments), there are finer thematic maps showing possible combinations of different indicators, which can be used as stand-alone tools in spatial planning and evaluation of investment projects.

The city will include the visual outputs into its open map portal after a public consultation process and a formal acceptance of the Atlas by a resolution of the City Parliament.

4 Conclusion and Lessons Learned

This paper presented a case study on a climate change impact and vulnerability analysis for the City of Bratislava, Slovakia. It shared some background on the state of the art for impact and vulnerability assessment and gave a brief introduction to the applied methodology. The paper described the initial situation in Bratislava at the outset of the process and detailed the application of the assessment methodology exemplarily for the effects of extreme rainfall on the road infrastructure in Bratislava.

While the initial goal of conducting an indicator-based vulnerability assessment followed by a multi-criteria impact and likelihood analysis could not be met due to lack in historical records, it was possible to conduct a non-probabilistic indicator-based assessment that reflects the present conditions in Bratislava. After further validation of the results by public consultation processes, a probabilistic assessment covering different climate change scenarios is planned, availability of sufficient historical records provided. This assessment should also employ a higher (i.e. sub-borough) resolution to enable detailed planning of adaptation options. This iterative refinement approach is in line with how impact and vulnerability analyses for climate change should be understood: as a continuous process with regular, frequent updates and adjustments accommodating new developments and newly available data.

In addition, applying the methodology in Bratislava showed the need for a European – or even globally – unified reference indicator set for impact and vulnerability analysis in urban areas with standardized temporal/spatial resolution and scope as well as standardized data structures to enable comparability between different urban areas and facilitate development of better supporting tools. The availability of reliable, sufficiently extensive data sources is a serious problem that limits the applicability of probabilistic assessment methodologies (see also BBK [22], p. 94, right box).

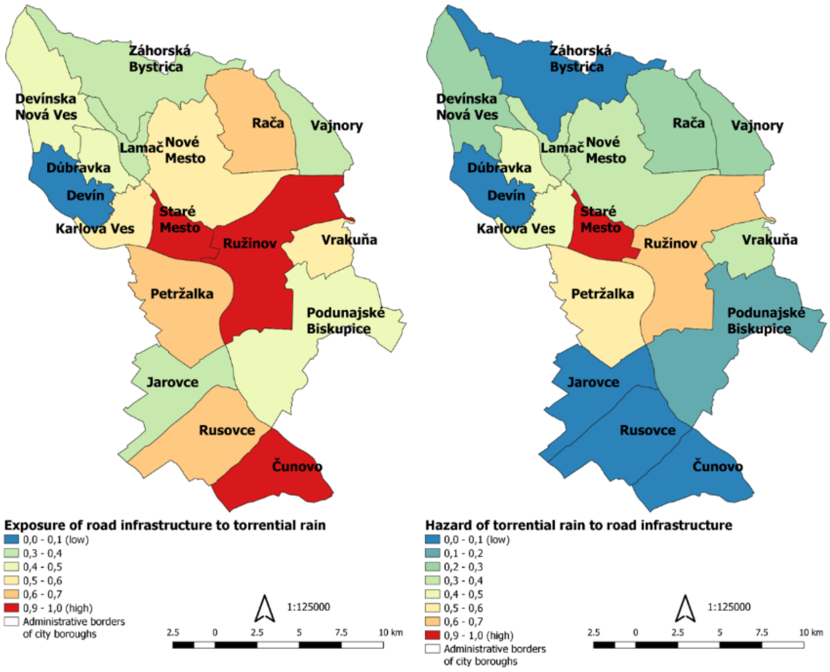

Fig. 4. Choropleth maps, left: Exposure of road infrastructure to torrential rain; right: Hazard indicator for torrential rain. Source: [4].

Nonetheless, non-probabilistic assessments are highly valuable for a multitude of stakeholders in urban areas. Developing cause-effect models with experts from different municipal departments facilitates joint understanding and better communication of complex climate change-related issues. Discussing these issues across different departments and stakeholder groups can also pave the way for other processes that enable a better assessment in the future. For example, as a result of applying IVAVIA in Bratislava, the Office of the Chief City Architect was invited to join a working group developing a GIS portal for Bratislava that can be employed for further refinement of the assessment results.

The results presented in the Atlas will be an important tool for identifying where to implement adaptation measures listed in the action plan for climate change, e.g. sustainable drainage systems, bio swales, green retention trenches and infiltration basins, rain gardens, or increased permeable paving. On a city-wide level, more initiative needs to be taken in terms of strategic land-use planning by incorporating the results of the assessment into the new master plan. While the city can do this in public spaces, private property owners also need to be incentivized to take action. For example, the city provides municipal grants of up to 1,000 € to encourage the implementation of adaptation measures in households, such as upgrading buildings with sustainable drainage systems or other nature-based approaches for rain water retention.

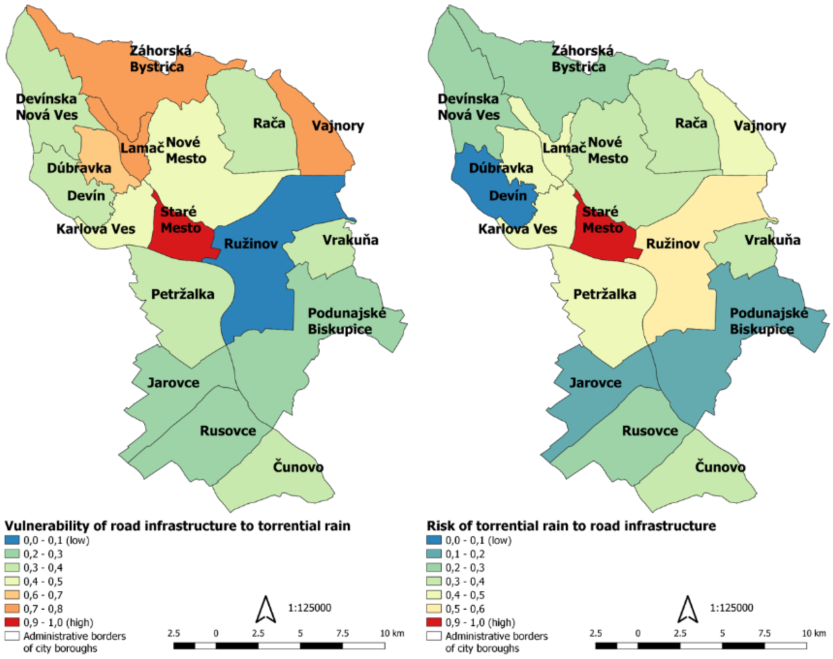

Fig. 5. Choropleth maps, left: Vulnerability of road infrastructure; right: Risk of torrential rain on road infrastructure. Source: [4].

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References

1. Intergovernmental Panel on Climate Change (IPCC): Summary for Policymakers. In: Global Warming of 1.5°C. World Meteorological Organization, Geneva, Switzerland, 32 pp (2018).
2. Coletti, A., De Nicola, A., Villani, M.L.: Building climate change into risk assessment. Natural Hazards 84(2), 1307–1325 (2016).
3. Rossetti, M A: Potential impacts of climate change on railroads. In: Workshop on the Potential Impacts of Climate Change on Transportation, Washington, D.C. (2002).

4. Streberova, E., Lückerath, D., Pauditšová, E., Kozová M., Pecho, J., Šteflovičová, M., Šteflovičová, M., Rehačková, T. (2019). Atlas of impacts of climate change in Bratislava City. 66p. Forthcoming. (in Slovak).
5. RESIN – Climate Resilient Cities and Infrastructures, http://www.resin-cities.eu/, accessed Nov 11, 2017.
6. United Nations Office for Disaster Risk Reduction: "National Disaster Risk Assessment", Words into Action Guidelines, UNISDR (2017).
7. German Federal Ministry for Economic Cooperation and Development: The Vulnerability Sourcebook. Concept and guidelines for standardised vulnerability assessments. Deutsche Gesellschaft für Internationale Zusammenarbeit, Bonn and Eschborn, Germany (2014).
8. German Federal Ministry for Economic Cooperation and Development: "Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk", Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Germany (2017).
9. Intergovernmental Panel on Climate Change (IPCC): Summary for Policymakers. In: Climate Change 2014. Part A: Global and Sectoral Aspects. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 1–32 (2014).
10. German Federal Office of Civil Protection and Disaster Assistance: "Method of Risk Analysis for Civil Protection". Wissenschaftsforum 8, BBK, Bonn (2011).
11. Pyrko, I., Howick, S., Eden, C.: Risk systemicity and city resilience. In: EURAM 2017, University of Strathclyde, 21.- 24.06.2017.
12. United Nations Office for Disaster Risk Reduction: "Disaster Resilience Scorecard for Cities", UNISDR (2017).
13. RAMSES – Reconciling adaptation, mitigation and sustainable development for cities, http://www.ramses-cities.eu/, accessed Dec 05, 2017.
14. SMR – Smart Mature Resilience, http://smr-project.eu, accessed Dec 05, 2017.
15. Rome, E., Bogen, M., Worst, R., Lückerath, D., Sojeva, B., Ullrich, O., Voss, H., Voss N., Xie, J.: IVAVIA Guideline, Annex to Deliverable D2.3 Realisation and implementation of IVAVIA. EU H2020 Project RESIN, Sankt Augustin, Germany (2017).
16. Rome, E., Bogen, M., Lückerath, D., Ullrich, O., Worst, R., Xie, J.: IVAVIA: Impact and Vulnerability Analysis of Vital Infrastructures and Built-Up Areas. In: Critical Information Infrastructures Security – 13th International Conference, CRITIS 2018, Revised Selected Papers, Springer Security and Cryptology No. 12,260, 2019, pp. 84-97.
17. Neves, A., Blondel, L., Brand, K., Hendel Blackford, S., Rivas Calvete, S., Iancu, A., Melica, G., Koffi Lefeivre, B., Zancanella, P., Kona, A.: The Covenant of Mayors for Climate and Energy Reporting Guidelines, EUR 28160 EN, doi:10.2790/586693 (2016).
18. Organisation for Economic Co-operation and Development (OECD): Handbook on constructing composite indicators: methodology and user guide. Technical Report, OECD Publishing, Paris (2008).
19. Faško, P., Lapin M., Pecho J. 2008. 20-YEAR Extraordinary Climatic Period in Slovakia. Meteorological journal 11, 2008, 99–105. (in Slovak).
20. Výberči, J., Pecho, J., Faško, P., Bochníček, J. 2018. Warm and cool spells in Slovakia (1951-2017) in the context of climate change. Meteorological journal 21 2018, 101 – 108. (in Slovak).
21. OpenStreetMap Contributors (2018): https://www.openstreetmap.org/
22. German Federal Office of Civil Protection and Disaster Assistance: Abschätzung der Verwundbarkeit von Bevölkerung und Kritischen Infrastrukturen gegenüber Hitzewellen und Starkregen, Praxis im Bevölkerungsschutz ; Band 11, BBK, Bonn, 2013.