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DECISION MAKING SUPPORT TOOLS FOR ADAPTATION TO CLIMATE CHANGE - A MINI REVIEW

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Abstract. *The climate trends and climate scenario for the Republic of Serbia show a continuous increase in annual average temperature and change in precipitation patterns. In line with the forthcoming national program for adaptation to climate change, the objective of this research is a brief review of relevant decision support tools. For this purpose, 150 tools from three databases had been analyzed: 1) Climate-ADAPT, European Climate Change Adaptation Platform 2) United Nations Framework Convention on Climate Change Adaptation Knowledge Portal database and 3) U.S. Climate Resilience Toolkit managed by the Climate Change Program of the National Oceanic and Atmospheric Administration. Tools are analyzed with respect to four criteria: adaptation aspect, spatial level, types and application.*

Key words: *decision-making, adaptation, climate change*

1. INTRODUCTION

The climate trends in Serbia over the last three decades indicate the constant increase in temperature and change in precipitation patterns. On the other hand, climate scenario for Serbia points towards a potential increase in the average annual temperature between 0.5°C and 6.0°C, towards the end of the century, compared to period 1971–2000. Furthermore, it anticipates increase in the annual accumulated precipitation of 6–18% for the period 2011–2040, followed by a decrease of up to 12% later in the century [1]. The effects of climate change certainly cannot be seen as an "independent risk factor", but rather as an amplifier of existing risks. Predicted climate change might further increase the already high risk of natural disasters in Serbia, especially risks from floods, droughts, and wildfires [2].

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The National Strategy for Climate Change with the Action Plan that is based on the *EU Climate and Energy Package* is yet to be developed. The Strategy should provide a coherent framework for activities for the period until 2020 and 2030. Additionally, it should propose the general framework for the period until 2050, especially for the issues related to greenhouse gas reduction. *Draft Law on Climate Change* considers a program for adaptation for the period 2021-2030, that should address the following aspects in particular: 1) the analysis of the socio-economic situation that influences adaptation to the changed climatic conditions; 2) the analysis of the observed climate change; 4) the analysis of the impact of climate change on sectors and systems; 5) the identification of the most vulnerable sectors; 6) a proposal for adaptation measures, with cost/benefit analysis; and 7) the identification of the recourses for priority adaptation measures and responsible institutions for their implementation. The updated *Report of Serbia towards United Nation Framework Convention for Climate Change* highlights the insufficient level of climate policy integration into sectoral and development strategies, as well as limited institutional and individual capacities, financial resources and awareness, for an adequate response to the expected effects of climate change [3]. Thus, for an efficient management of the adaptation process and implementation of the adaptation policies at the sub-national levels, there is a need for development of relevant decision support systems and tools.

Decision support systems (from here on DSS) are developed to provide solutions for non-structural management problems, i.e., to improve the decision-making process. DSS are mostly used in strategic planning. Their importance is seen in the synchronization and integration of data from various sources in a form that can clearly inform decisions [4]. DSS can be used to raise awareness and readiness to respond to certain risks, and consequently, mitigate potential negative effects and reduce the vulnerability of the population to a particular risk [5]. Also, some interpretations of DSS incorporate a wider set of elements, like the knowledge management networks [5]. In that respect, these systems include so-called "decision-making instruments", developed to support different phases of decision-making. They include various types of tools such as models, maps, scenarios, planning guidelines, etc. In this paper, we particularly focus on these instruments under the umbrella term "tools". Complex domains, such as climate change, pose a specific challenge for tool development because such domains imply a high degree of uncertainty while planning, and consequently require sufficiently flexible decision-making process, capable to handle continuous changes.

Understanding the adaptation process requires specific expert knowledge and tools that are not necessarily an integral part of the existing planning practice in a certain context (e.g. the assessment of transport sensitivity to climate change). For an adaptation planning that considers a wide range of spatial and management levels and planning aspects, a number of tools have already been developed. Nevertheless, many of those tools are context-specific and can either serve only as models, or involve adjustments for use in other contexts.

2. METHODOLOGY

Taking into account the forthcoming national adaptation planning program, the objective of this research is to provide a brief review of adaptation tools developed by relevant institutions from various fields such as environmental protection, climate change, and risk management, and thus, shade a light on some of their main characteristics.

Three databases have been analysed for the purpose: 1) *Climate-ADAPT* European Climate Change Adaptation Platform;[2] 2) *United Nations Framework Convention on Climate Change Adaptation Knowledge Portal* database[3] and 3) *U.S. Climate Resilience Toolkit* managed by the Climate Change Program of the National Oceanic and Atmospheric Administration (NOAA)[4]. From the first database, 57 out of total 72 tools were analyzed. In case of the second and third databases, the key phrases in available filters were used for the extraction of tools specifically related to the adaptation planning process. In the first database, two filters were applied: 1) information - "*Toolkit*" option was selected, 2) adaptation element - "*Adaptation planning and practice*" option was selected. No additional filters were applied for the geographical region, sector, and climate risk. As a result, 120 tools were selected from this database. In the second database, only the filter for the function is used - "*Adaptation planning support*" option was selected. As a result, 97 tools were selected from this database. All 217 tools are additionally filtered. The tools that did not directly contribute to some of the adaptation aspects (e.g. vulnerability assessment, monitoring & evaluation) were not taken into consideration for further analysis (e.g. the *Federal Crowdsourcing and Citizen Science Toolkit*). Finally, 150 tools were selected and further analysed in relation to the four criteria:

1. Adaptation aspect - indicates for which planning phase a tool was designed.
    a. Impact assessment
    b. Vulnerability assessment
    c. Climate scenario development
    d. Monitoring and evaluation
    e. Knowledge management and capacity building
    f. Selection of adaptation measures
2. Spatial level - indicates the spatial level at which the tool can be applied
    a. Community level
    b. Municipality/city level
    c. National level
    d. Global level
3. Type - defines the type of tool
    a. Multi-criteria analysis MCA
    b. Simulation models
    c. Cost Benefit Analysis/ Cost Effectiveness Analysis
    d. Planning guidelines
4. Application - indicates whether the tool is formulated for a single case application or it offers the possibility of comparison with other cases
    a. Single case application
    b. Allows comparison

[2] https://climate-adapt.eea.europa.eu/data-and-downloads#b_start=0
[3] http://www4.unfccc.int/sites/nwp/Pages/Search.aspx
[4] https://toolkit.climate.gov/tools

3. ADAPTATION TOOLS ANALYSIS

The analysis indicates that most of the tools refer to more than one adaptation aspect (e.g., climate scenario development, monitoring and evaluation), and cover adaptation planning process generally. Namely, 54% of all analysed tools were designed for, more or less, general purposes. They can be applied to different sectors for the analyses of various adaptation elements, or for vulnerability assessments of different receptors. A large number of tools from this cluster include step-by-step adaptation planning guidelines/manuals with integrated catalogues of adaptation measures, climate scenarios or the examples of good practice (e.g. *Climate Action Tool*, *Adaptation Compass*). These tools are especially useful in the initiation phase – definition of the scope of adaptation, receptors, stakeholders, spatial scale, priority risks, etc. However, when it comes to specific planning tasks (e.g., detailed climate impact assessment) they often refer to the external resources.

The remaining 46% of the tools are more specifically designed, either for a particular sector, or climate impact, i.e. they are designed to provide particular data as input information for the development of relevant adaptation response. This cluster can be divided into two sub-sets. The first sub-set includes software-based packages designed for the assessment of climate impacts or vulnerability from risks such as floods, sea level rise, heat islands and droughts, through simulation and models (e.g., *Drought Stress Quick Scan*). These tools often provide information on the risk levels and spatial distribution of the impacts observed or vulnerable receptors with regard to an observed stressor. They often require specific expert knowledge, which might be a constraint for their use in less developed areas that often lack trained professionals. The second sub-set includes sector-specific decision support platforms (e.g. *Climate-Smart Conservation*).

Adaptation aspects. The result of the analysis of the first criterion is shown in Figure 1. The majority of analysed tools fully or partially relate to three phases of adaptation planning: knowledge management and capacity building (41%), vulnerability assessment (35.1%), and

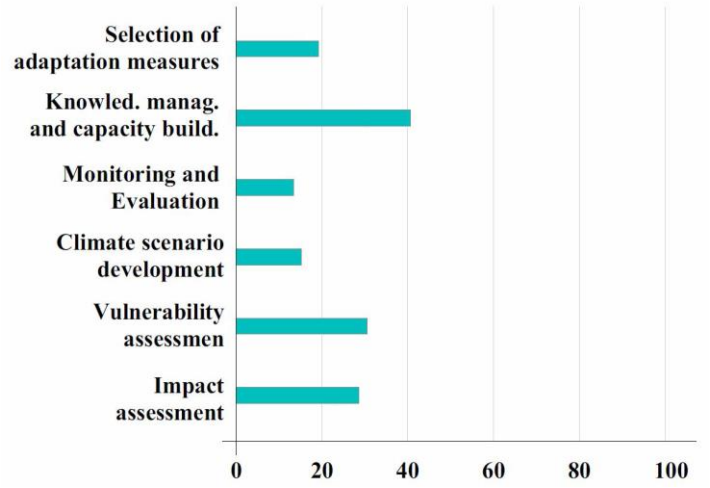

Fig. 1 Adaptation aspects

impact assessment (33.1%). They include tools designed for the mapping socioeconomic data, institutional capacity analysis, participative planning manuals, and the like (e.g., interactive climate trends and projections, relevant literature, case studies, etc.) as well as the tools focused on vulnerability and climate change impacts as main adaptation elements (e.g., the *NatureServe Climate Change Vulnerability Index*). The distribution of tools aimed for different phases of adaptation planning, obviously reflects the demand for essential knowledge/expertize and a basic understanding of the potential risks from climate change. Accordingly, these adaptation phases are also the most advanced in practice.

Although the abovementioned tools provide some inputs for adaptation planning, only 19.4% of the analysed tools are designed for adaptation measures prioritization, as a decision support. Some of those tools, like *Climate Action Tool* (*University of Massachusetts Amherst*) or *Coastal EBA Options (UNEP)*, are composed as on-line instructions with integrated sets of predefined measures based on case studies, where the adaptation measures are selected using an analogy with a particular reference from the set of measures regarding the particular stressor (e.g., flash floods). Similarly, the tool entitled *Identifying and Evaluating Adaptation Option* (*The Biodiversity Convention*), provides a list of relevant adaptation measures, using a matrix formed in accordance with defined spatial criteria and type of adaptation (e.g., forest management).

Catalogues of measures are systematized adaptation options in respect to climate impacts, vulnerable groups, the sector at risk or other relevant categories. They give decision-makers access to accumulated practical or procedural knowledge, essential for defining adequate adaptation response. Although some of the tools (e.g., *Cities Impacts & Adaptation Tool*, *Adaptation Compass*) include more detailed descriptions of the characteristic of offered measures in integrated databases, most of the tools lack essential information on the decision-making process form which those measures were selected and later proved as examples of good practice. These aspects may include, for instance, a set of criteria according to which the measure was selected, current status in the implementation process, validation period, constraints for implementation and monitoring, financing method, aspects of uncertainty and risks involved in a decision process, social acceptability, etc. The integration of these aspects can provide valuable information for decision-makers when selecting a relevant measure.

Only a few tools designed as applications and software packages, such as *Climate Adaptation Options Explorer - ADX*, apply multi-criteria decision making methods (e.g., Analytical Hierarchical Process). Based on input criteria, such as climatic and socio-economic scenarios, these tools perform a ranking of priority adaptation measures. The result of the application of such a tool is the ranking of measures based on the obtained specific weights. The last two clusters include various tools for spatial interpretation of climate scenarios and aspects of monitoring and reporting.

Spatial level. The results of the analysis contribute to the argument that the local level is an optimal spatial level for the initiation of adaptation planning [6, 7]. In terms of coverage, most of the tools are applicable at more than one spatial level. However, the largest number of tools, as much as 75%, can be applied at the city or municipality level (e.g., *The Citi RAP Tool*, *PluviAG*) (Figure 2). This high percentage can be explained by the fact that at the local level, the resolution of data can be directly used in the decision-making process (for example, the inventory of potentially vulnerable parts of the city to floods). The local level provides the opportunity for inclusion of detailed information and

more precise understanding of the complexity of the phenomenon. However, the often disused issue of overcoming the conceptual problems related to the data resolution and the spatial level for which the assessment is carried out [8] remains unaddressed within the group of the analysed tools.

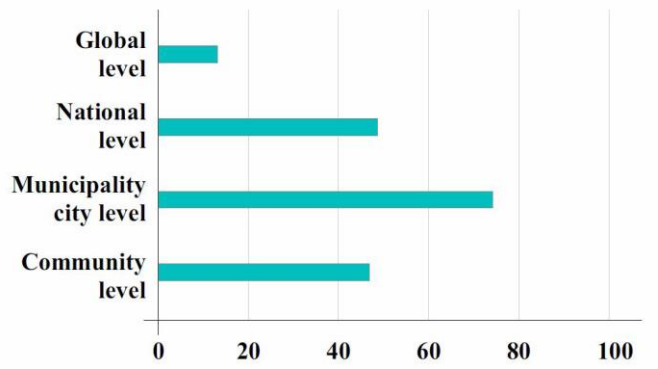

Fig. 2 Spatial level

Type of tools. The analysis of the first criterion (adaptation aspects) points to knowledge management and capacity building, and vulnerability assessment as the most represented aspects of adaptation planning process, when it comes to decision support tools. Accordingly, when it comes to types of the tool, instructions and planning guidelines dominate (55.8%) (e.g., *Vulnerability Sourcebook*, *The Urban Adaptation Support Tool*, *Adaptation Workbook for Land Management and Conservation*, *Local Authority Adaptation Wizard*) (Figure 3). Essentially, these tools represent methodologies and instructions for planning supported by specific databases. The remaining tools include climate impacts/scenarios simulation models (36.4%), tools for economic evaluation of adaptation options (7%) and multi-criteria analysis apps. (2%) (e.g., *Aquarius*, *Waterware*).

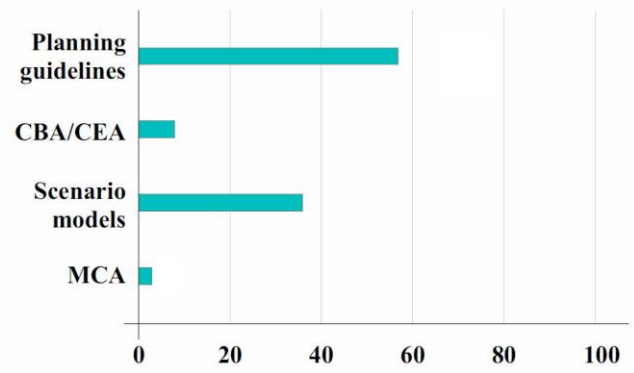

Fig. 3 Type of tools

Application. When it comes to the last criterion, most of the tools are designed to address individual cases (75%), whether it is about the choice of one adaptation measure, the assessment of one impact, or the focus on one sector or aspect of planning (e.g., *AgBizClimate*). Although the results obtained using these tools can be compared to each other through a case-by-case application of a particular tool, tools are not conceptually defined to offer a comparison between the cases as the one of decision support elements. A smaller number of tools (25%) provide that option. In this context, the comparison is seen as the ability to analyse different elements of adaptation at different spatial levels in the process of selection of adaptation measure. For example, the possibility of comparison urban flood adaptation plans between cities or municipalities that share a common property (e.g., topographic characteristics, governance structure, population density), can add to a better understanding of pros and cons of particular adaptation measures to floods in a similar context. Comparison also supports the transfer of knowledge in the decision making process and, therefore, adds to the capacity building.

4. CONCLUDING REMARKS

Many of the previously mentioned tools, to a certain extent overlap in terms of the analysed criteria and the methodological approach. The analysis points to a greater share of tools that focus on the organizational – general level of adaptation planning and the aspects of impact assessment and vulnerability. On the other hand, it reveals marginal share of tools that are in the direct function of the selection of adaptation measures. This is mostly due to the fact that climate impacts and possible responses are dependent on regional differences that, accordingly, often call for context-sensitive adaptation options.

A number of tools for the selection of adaptation measures are a part of the larger decision support systems that also include other elements of adaptation planning, and thus, should be evaluated as such. However, most of them focus on the effects of the single measure or impact, and respective vulnerability. It is important to take into account that vulnerability implies the dynamics, because by the time adaptation capacity is improved due to application of an adaptation measure, a relative degree of vulnerability changes accordingly. In practice, adaptation to climate change is a continuous process of improving the knowledge of the vulnerability of the observed system and evaluating the effectiveness of the applied measures to reduce the observed risk from particular climate impact. It also requires an understanding of the cumulative impact of the set of measures on the degree of adaptive capacity of the certain receptor (e.g., sector, system, vulnerable population). The synergic impact of a set of measures is not sufficiently addressed aspect in the tools analysed.

At the national and sub-national levels in Serbia, a common decision support system for climate adaptation planning has not yet been developed. This review highlights only some aspects of the decision support tools form the selected databases, which can serve as a direction for further in-depth analysis. The development of adaptation tools and DSS in Serbia should certainly require the international examples to be considered, as well as characteristics of local planning practices and needs. Thus, a further research should, among others, consider the following aspects: 1) the analysis of tools used in local strategic planning so far, 2) different spatial and governance levels of natural hazards risk management practices, and 3) the assessment of professional capacities and expertizes at the local level.

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PREGLED ALATA ZA POMOĆ ODLUČIVANJU U PLANIRANJU PRILAGOĐAVANJA EFEKTIMA KLIMATSKIH PROMENA

Klimatski trendovi i klimatski scenario za Republiku Srbiju pokazuju kontinuirano povećanje prosečne godišnje temperature i promene ukupne prosečne količine padavina. U skladu sa predviđenim nacionalnim programom prilagođavanja efektima klimatskih promenama, cilj ovog istraživanja je kratak pregled relevantnih alata za podršku odlučivanju. U tu svrhu je analizirano 150 alata iz tri baze podataka: 1) Climate-ADAPT, evropska platforma za prilagođavanje klimatskim promenama 2) Portal za Upravljanje Znanjem u Prilagođavanju na klimatske promene Okvirne Konvencije Ujedinjenih Nacija i 3) "United States Toolkit" pod upravom Programa za klimatske promene Nacionalne uprave za okeane i atmosferu (NOAA). Alati su analizirani u odnosu na četiri kriterijuma: aspekt prilagođavanja, prostorni nivo, tip alata i primenu.

Ključne reči: *odlučivanje, prilagođavanje, klimatske promene*