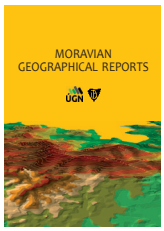

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An opportunity missed is an opportunity lost. Flood maps and their (non-)utilization by local government bodies in the Czech Republic

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Abstract

Flood maps are a crucial component of integrated flood risk management. While their key role is commonly acknowledged by experts and scholars, however, literature and findings on the practical utilization of flood maps (including the user' experiences) within the processes of governance are scarce. Our study aims to contribute to closing this gap; by focusing on the Czech local government bodies, data collected through a questionnaire survey allowed us to examine (a) how, or whether at all, the officials employ flood maps in their agendas; (b) how do they experience and assess working with the maps; and (c) which data would they supplement the extant flood maps by. Our findings show that the praxis of local flood-related governance in the Czech Republic still largely neglects the up-to-date approaches and practices of flood risk management. The officials addressed mostly continue to rely on the earliest type of floodplain maps and purely technical aspects of floods, while largely omitting the newer flood danger and risk maps; thus, they are also missing the opportunities of applying multi-criteria assessment of the flood risk and more effective communication with the public. The paper concludes with a set of suggestions for relevant praxis and future research.

Keywords: *Flood maps, flood risk management, local government bodies, questionnaire survey, Czech Republic*

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1. Introduction

Floods are one of the most severe and damaging extreme weather events, moreover with a projected increase in their future adverse impacts (Mohanty & Simonovic, 2022; Newell et al., 2016). Complete flood protection is unattainable, and the reliance on strictly technocratic approaches and solutions to the manifold flood-related issues, including the preference for the public-engineered (or so-called structural) measures, proved to be inadequate (Buchecker et al., 2016; Glosińska, 2014; McEwen et al., 2018; Santoro et al., 2022; Schober et al., 2015). Accordingly, the attention of academics, experts, and policy-makers turned to what is termed integrated flood risk management (Bodoque et al., 2019; Bubeck et al., 2012; Fuchs et al., 2017; Schelfaut et al., 2011), and the respective fields of research, knowledge, and practical applications recently witnessed the introduction, application, and further advancements of a wider spectrum of tools and measures available to improve our understanding of risk and support flood preparedness (Andráško, 2021; Glosińska, 2014).

Without a doubt, flood maps represent one of the crucial components of these developments, gaining growing attention not only within the respective research (Albano et al., 2015; Dottori et al., 2022; Mudashiru et al., 2021; Müller, 2013), but also as regards the policy-making processes, planned interventions, and legal frameworks such as the Floods Directive 2007/60/EC.

In this study, we focused on whether and how local government bodies in the Czech Republic utilize (particular types of) flood maps within the relevant planning and decision/policy-making processes. Since the respective field of knowledge is largely under-investigated so far, with the extant findings rather scarce, the study was exploratory, focusing on the following research questions:

- How, or whether at all, do the local government bodies utilize (individual types of) flood maps available to conduct their governance-related activities?
- How do the local government bodies experience working with flood maps?

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- How are (if at all) the local government bodies aware of/informed about flood maps available?
- How do the local government bodies comprehend and interpret the contents of flood maps?
- Which data/information the local government bodies consider necessary to be added to the flood maps?

2. Theoretical background

2.1. Flood maps as a part of integrated flood risk management

Important flood prevention measures include, among others, increasing flood awareness and improving flood communication. It is argued that through flood maps, flood-related information can be obtained in a graphical/visual form facilitating its understanding and acceptance, and thus reinforcing risk awareness (Albano et al., 2017; Kjellgren, 2013; Munz et al., 2023), and, eventually, flood preparedness (Birkholz et al., 2014; Bradford et al., 2012; Klemešová & Andráško, 2015; Mondino et al., 2020; Ridolfi et al., 2021; Santoro et al., 2022). Hence, various flood maps (Section 2.3) increasingly come to the fore as essential instruments and means of a) more competent decision-making and land-use planning (*cf*. Kopp et al., 2021); b) raised adaptive and coping capacities in flood-prone areas; and c) improved risk communication between particular levels of governance, experts, and authorities involved, but also, at least potentially, the lay public (Auliagisni et al., 2022; Kjellgren, 2013; Porter & Demeritt, 2012).

Compared with the body of literature and findings on the respective methodologies and technicalities (de Moel et al., 2009; Dráb & Říha, 2010; Hagemeier-Klose & Wagner, 2009; Heintz et al., 2012; Meyer et al., 2012; Mudashiru et al., 2021), however, including current improvements in terms of the underlying data and application of new technologies (Beden & Ulke Keskin, 2020; Gebrehiwot & Hashemi-Beni, 2020; Jiun-Huei et al., 2022; Kim et al., 2020), other aspects of flood maps remain rather under-investigated. Despite the valuable work done so far, this holds as regards the perceptions (Houston et al., 2019; Maidl & Buchecker, 2015; Sanders et al., 2020; Seipel & Lim, 2017) and practical utilization of flood maps by particular target groups (Auliagisni et al., 2022; Minucci et al., 2020). In the Czech Republic, there is currently, to our best knowledge, a complete lack of such research.

An important target group for the implementation of flood risk management is the public governance. Accordingly, our research centred on the usage of flood maps by the officials of local governments; these bodies play a key, yet often also largely contested and complicated role in the complexities of planning interventions, policy implementations, or reconciliation of various interests (Frantál et al., 2023; Handmer, 1996), including the mediatory position in the communication between agents such as governments, authorities, experts, entrepreneurs, local inhabitants, and others. Governments (including the local ones) and other authorities commonly officially acknowledge the importance of getting along with and implementing the up-to-date developments of the flood risk management approaches, including the wider utilization of flood maps to address the flood risk, within their everyday duties, tasks, and overall professional conduct; on the other hand, extant research suggests that such steps and measures too often remain rather declared than actually taken and utilized (Henstra et al., 2019; Rauter et al., 2020; Slavíková et al., 2019; Vávra et al., 2017).

2.2 The origins of flood mapping in Czechoslovakia/Czech Republic and the impact of joining the European Union

While the first flood marks indicating the level of flooding at a given location were mentioned already in the 15th century (Munzar et al., 2006), more sophisticated methods of flood mapping found their way into the legislation only throughout the second half of the 20th century (Tab. 1) (*cf.* e.g. Porter & Demeritt, 2012).

2.2.1 The Floods Directive 2007/60/EC

An important milestone for flood mapping is the adoption of the European Floods Directive (2007/60/EC) in 2007 and its subsequent transposition into the Czech legal framework (Water Act No. 254/2001 Coll.). Implementation was carried out in 2009 by the Ministry of the Environment. From the territorial perspective, the issue of flood management concerns the Czech parts of three international river basins – Elbe, Danube, and Odra.

Three follow-up phases of implementation of the Floods Directive are reviewed and updated in six-year cycles. The implementation phases are listed below within the schedule of the first planning cycle, which the Czech Republic has prepared in accordance with the requirements of Chapters 2, 3, and 4 of the Floods Directive in the same way as other member states (Vermeulen et al., 2019): i) preliminary flood risk assessment (end of 2011); ii) creation of flood hazard and flood risk maps for areas at significant flood risk (end of 2013); and iii) creation of comprehensive Flood risk management plans (end of 2015).

As part of the preliminary flood risk assessment, areas at significant flood risk were identified. These areas were defined according to the number of potentially affected permanent residents (minimum 25 inhabitants/year) and/or the value of potentially affected property in the affected municipalities (minimum CZK 70 million/year) (TGM WRI, 2012). In the second phase of implementation, flood hazard and risk maps for different flood scenarios corresponding to low, medium, and high probability of flood occurrence were prepared for these defined areas (see Section 2.3 for more details). The maps subsequently became part of the Flood risk management plans. These plans are an important conceptual document that sets out the objectives and measures for flood risk management in a binding manner (Záruba, 2022). They serve as a basis for the exercise of public governance, in particular for spatial planning and water management in areas at significant flood risk, altogether aiming to manage flood risks effectively (for more details, see e.g. Alexander et al., 2016).

Similarly to other countries, for example, Poland (Hegger et al., 2013), the central government in the Czech Republic plays a major role in flood protection, operating through national and regional water agencies. Legislation at the national level is primarily issued by the Ministry of the Environment, and processing of the preliminary flood risk assessment and its subsequent updates falls under the responsibility of the T.G. Masaryk Water Research Institute (hereafter TGM WRI). This nationally funded institute has also developed a uniform methodology for the creation of flood hazard and flood risk maps (TGM WRI, 2012). The methodology was subsequently approved by the Ministry of the Environment, and the State enterprises of river basins were the producers of each type of map (flood hazard, flood danger and flood risk maps). The costs are covered by the state budget. In order to preserve one of the principles of the Floods Directive, namely public participation in the process, Decree No. 50/2023 Coll., stipulates that the public has the right to be heard (i.e. to express their concerns) within each phase of the implementation of the Directive (including the updates) within the comment procedure following the implementation of the phase.

The Floods Directive changes the approach to dealing with floods from one focused on local protection to one concerned with comprehensive flood risk management, centred also on prevention and preparedness. Similarly to other European countries (Vermeulen et al., 2019), there is not yet sufficient information in the Czech Republic to claim to what extent the implementation of the Floods Directive has succeeded in reducing flood risk.

Legal regulation No.	Title of the legal regulation	Force	Integration of flood mapping
175/1953	Decree of the Ministry of the Interior on flood protection	Repealed 1959	The requirement to produce flood maps indicating hazardous areas where floods, ice barriers, etc. may form.
126/1959	Decree of the Ministry of the Interior on flood protection	Repealed 1975	The text of the decree has not been preserved.
27/1975	Regulation of the Government of the Czech Socialist Republic on flood protection	Repealed 1999	Required only ex-post recording of flooded areas, ice barriers etc. in flood plans.
100/1999	Regulation of the Government of the Czech Republic on flood protection	Repealed 2002	The requirement that flood plans must include a graphic section containing information on, inter alia, floodplains.
254/2001	The Water Act	In force since 2002	Until 2009, the requirement for: 1) flood plans must include a graphic section containing information on, *inter alia*, floodplains; 2) the production of floodplain maps and active flood zones. Amendment in 2010 – incorporated articles on flood mapping resulting from the transposition of the Floods Directive requiring the production of flood hazard and flood risk maps (Section 2.3).
236/2002	Decree of the Ministry of Environment on the method and scope of design of floodplains	Repealed 2018	Detailed requirements for the design of the floodplains and the determination of the active flood zones.
24/2011	Decree on river basin management plans and Flood risk management plans	Repealed 2023	Detailed requirements for preliminary flood risk assessment, content and method of creation of flood hazard maps, flood risk maps, and forms of their publication.
79/2018	Decree of the Ministry of Environment on the method and scope of design of floodplains	In force since 2018	Detailed requirements for the design of the floodplains, determination of the active flood zones, and creation of flood danger maps.
50/2023	Decree on river basin management plans and Flood risk management plans	In force since 2023	Detailed requirements for preliminary flood risk assessment, content and method of creation of flood hazard maps, flood risk maps, and forms of their publication. Compared to Decree No. 24/2011 Coll., expansion of scenarios for the creation of flood hazard and flood risk maps.

Tab. 1: The most important legal regulations of Czechoslovakia and the Czech Republic entailing requirements for different levels of flood mapping. Source: authors' processing using ASPI legal software

2.3 Flood maps in the context of Czech legislation and transposition of the Floods Directive

There are four types of flood maps[1] codified in Czech legislation. These maps are used by the public governance: namely, i) Floodplain maps; ii) Flood hazard maps; iii) Flood danger maps; iv) Flood risk maps. Amongst these closely interconnected flood maps[2] (see Fig. 1), flood hazard maps (see also Section 2.3.2) are important mainly from the theoretical and methodological perspective; there is an obligation to create them, stemming directly from the Water Act, and they serve as an intermediate step for the creation of flood danger maps (§ 5 of Decree No. 79/2018 Coll.). On the other hand, from the viewpoint of their utilization by local public authorities in statutory cities, these maps do not serve as an independent basis for decision-making. That is why they were not part of our empirical research (i.e. the questionnaire survey and analyses; Section 3 onwards). The terminology of flood mapping was not uniform in the past in the Czech Republic (Dráb & Říha, 2010); in this paper, we draw on the terminology of the Floods Directive and the Methodology of TGM WRI (TGM WRI, 2012).

2.3.1 Floodplain maps

Floodplain maps show the floodplains bounded by the flood line for the flood scenarios Q5, Q20, Q100, and Q500 (flood occurrence that is reached or exceeded on average once every 5, 20, 100, and 500 years) (§ 2 of Decree No. 79/2018 Coll.). They represent a purely technocratic approach to flood risk assessment using hydraulic modelling and other supporting documents defined in § 4 of Decree No. 79/2018 Coll. Floodplains are one of the bases for flood hazard maps (see Section 2.3.2). For built-up areas, there are also active flood zones defined as parts of the floodplains. "An active zone is an area in the built-up areas of municipalities and in areas designated for development according to Local plans that drains a decisive part of the total flow during a flood event and thus poses an immediate threat to human life, health, and property." (§ 2 of Decree No. 79/2018 Coll.). To define active flood zones more precisely, flood hazard and flood danger maps (Q100) must be used for the task and given section of a watercourse since 2018 (Decree No. 79/2018 Coll.).

The processing and updating of floodplains are dealt with by watercourse managers and approved by the water authority. Floodplain maps have been prepared at a scale of 1:10 000 (*cf.* Porter & Demeritt, 2012), since 2018 in a uniform graphic format (Decree No. 79/2018 Coll.). There is no single official source/storage/map application, however, where a guaranteed and always up-to-date floodplain layers for the whole territory of the Czech Republic watercourses, including small streams, could be found (Klemešová, 2016). Thus, official data are primarily collected from the managers of the given watercourses, who also obligatorily submit their data for the Planning analytic materials (see Section 2.3.6).

2.3.2 Flood hazard maps

Using designated floodplains, flood hazard maps identify areas that could be flooded under different flood scenarios (§ 64a of the Water Act). The essence of the flood hazard statement is the determination of the spatial distribution of the characteristics of the flood extents[3], flood depths, and flow velocities, and their processing into flood hazard maps for the flood scenarios Q5, Q20, Q100, and Q500 (TGM WRI, 2012, § 17 of Decree No. 50/2023 Coll.). Flood hazard maps quantify flood hazard via hydraulic calculations and the evaluation of flood intensity. Subsequently, they are used as a basis for the creation of flood danger maps (see Fig. 1). Flood hazard maps are prepared for areas at significant flood risk at a scale of 1:10 000.

[1] The fifth existing type of flood maps in the Czech Republic are flood insurance maps, which are not codified in Czech legislation. These are only used in the commercial sphere and they are therefore not the subject of this study. For more about flood insurance maps see e.g. Klemešová (2016).

[2] When addressing the technological, methodological, or processing-related aspects of flood-risk mapping in general, we refer to these maps in the paper collectively as the "flood maps".

[3] They use existing floodplain maps that exist for all areas at significant flood risk.

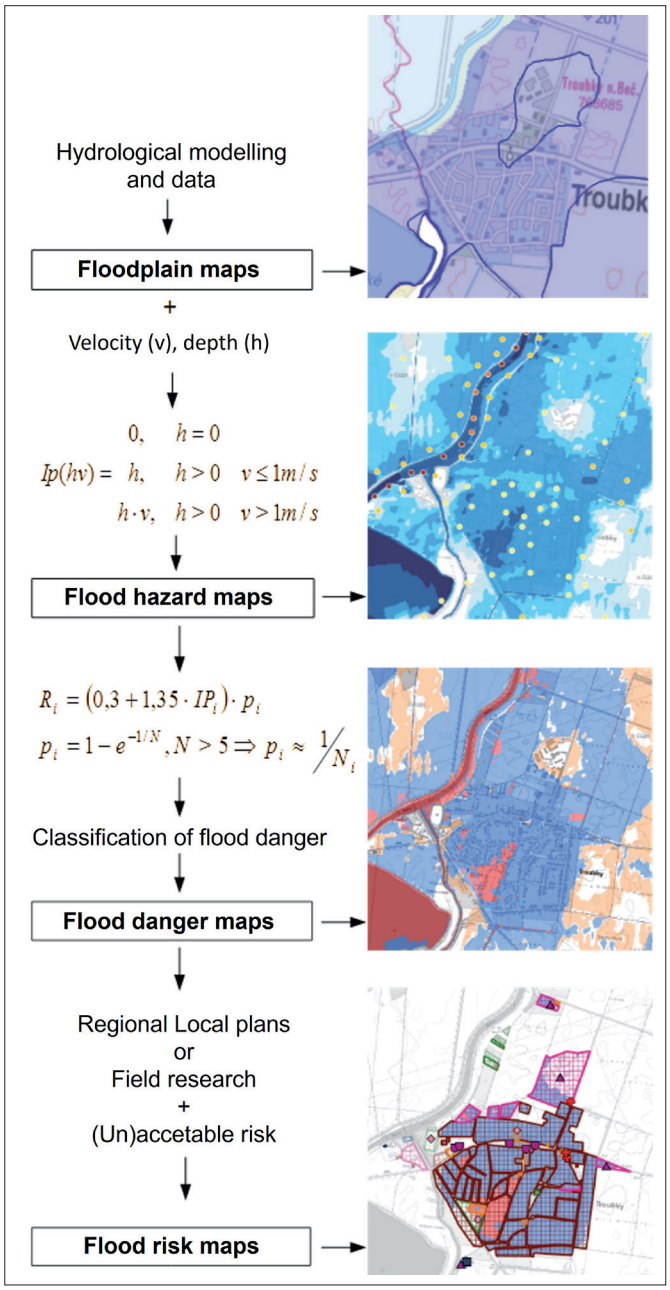


Fig. 1: Four types of flood maps and their interconnection – the example of Troubky village (R_i = flood danger; I_{Pi} = flood intensity of a given flood scenario; p_i = probability of occurrence of a given flood scenario; N_i = return period in years)
Source: modified from Klemešová (2016)

2.3.3 Flood danger maps

Flood danger maps represent/demonstrate the level of threat to a flooded area on a four-level scale, determined as a combination of the probability of occurrence of an undesirable event and the flood hazard (§ 17 of Decree No. 50/2023 Coll.). Then, the danger can be high, medium, low, and residual (§ 2 of Decree No. 79/2018 Coll.) (Fig. 2). The maps are prepared for areas at significant flood risk at a scale of 1:10 000. The matrix method is used, which does not require a quantitative estimation of the damage caused by water discharge from the channel but expresses the flood danger using a matrix categorizing flood-prone areas due to their relative level of threat expressed by a colour scale (Dráb & Říha, 2010).

The uniform TGM WRI methodology (2012) has its drawbacks: for example, its use for flood danger maps results in difficulties in interpreting the blue colour, traditionally and even somehow intuitively associated with the extent of flooding (Hagemeier-Klose & Wagner, 2009; Klemešová et al., 2014; Ministry of Transport and Water Management of the Netherlands, 2007). In flood danger maps, the blue colour indicates a medium level of flood danger (see Fig. 2). This issue comes to the fore even more when considering the maps as a means of effective risk communication with the lay public (Hagemeier-Klose & Wagner, 2009). A more appropriate scheme seems to be the alternative of the so-called traffic light display (green, yellow, orange, red) used for example in Romania (Vermeulen et al., 2019).

2.3.4 Flood risk maps

The flood risk maps focus on the potential adverse consequences associated with particular flood scenarios (Q5, Q20, Q100, Q500) (§ 64a of the Water Act). They are based on flood danger maps and area vulnerability. For each category of land use (for example, housing, transport infrastructure, agricultural land) the level of acceptable risk is determined. The flood risk maps show the areas of each land use category where the level of this acceptable risk is exceeded (TGM WRI, 2012) (Fig. 3). Maps are prepared for areas at significant flood risk at a scale of 1:10 000. Relying not only on the hydrological modelling but also on the information on land use and vulnerability, the flood risk maps represent a shift toward a multi-criteria flood risk assessment (Klemešová et al., 2014; Konečný, 2011).

2.3.5 Comparison of flood maps from the perspective of flood management developments in the Czech Republic

Besides others, the differences between the four types of maps also aptly illustrate the respective developments in flood risk management; exemplary is in this case the altering conceptualization and incorporation of flood risk, commonly defined as a function of threat and vulnerability, or, more specifically, as (the combination of) the probability of a flood event and its adverse consequences for human beings/society (Floods Directive, 2007, Few & Matthies, 2006). The earliest types (floodplain maps) are based on purely technocratic approaches relying on hydrological modelling and probability calculations. More recent types (flood danger and risk maps) involve, to some extent, also the aspects of perceptions, experience, and social construction of risk (Andráško, 2021), by applying flood danger categories, and zones of acceptable and unacceptable risk identified through land use data, spatial planning documents, but also personal knowledge of the area (Klemešová, 2016).

Nevertheless, these aspects still regard only experts (map makers) and particular methodologies (Hagemeier-Klose and Wagner, 2009; Minucci et al., 2020). Thus, while public hearings are sometimes held, their outcomes are, as affirmed by authors' professional experience, not sufficiently (or not at all) incorporated in the (processes of creation of) flood maps yet; the potential to, for example, refine the boundaries between areas of acceptable and unacceptable risk based on knowledge from the personal experience or memories (Atreya et al., 2017; Auliagisni et al., 2022; Harclerode et al., 2016; Markanday & Galarraga, 2021) of those who came through a particular flood event(s) at the place in question, then remains largely underutilized. Moreover, the underappreciation of the lay, yet often very rich and practical understanding of floods (Duží et al., 2017; Jakubcová et al., 2016; Vaishar et al., 2000; Vávra et al., 2017), including a certain proficiency in dealing with them, may weaken the local inhabitants' trust and interest in, and utilization of, the "made by some experts" measures (including the flood maps); the public's future willingness to support respective interventions and engage personally in the decision-making processes and bearing the burden of mitigating floods and their consequences may be negatively affected this way as well (Begum et al., 2007; Kundzewicz, 2004; Raška & Dubišar, 2017).

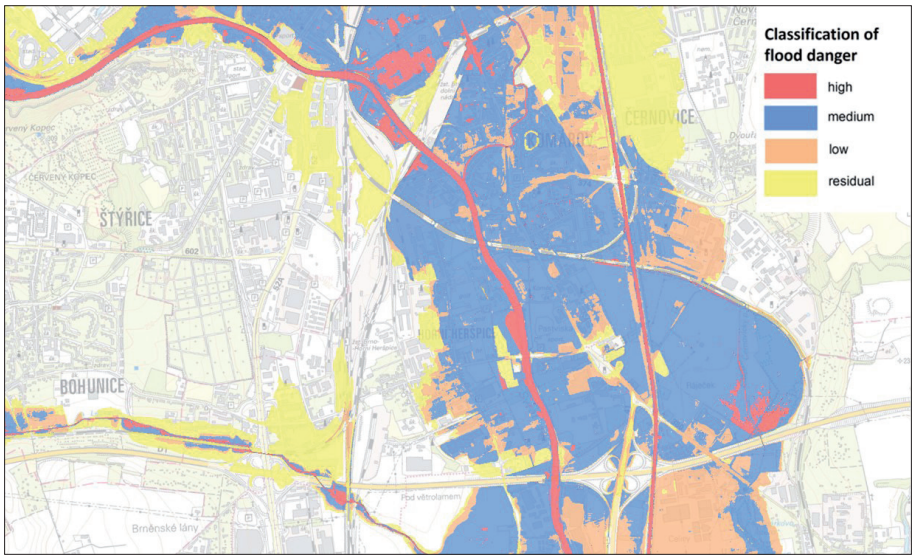


Fig. 2: An example of a flood danger map from Central Data Storage – Statutory city of Brno
Source: modified from Ministry of Environment of the Czech Republic (2021)

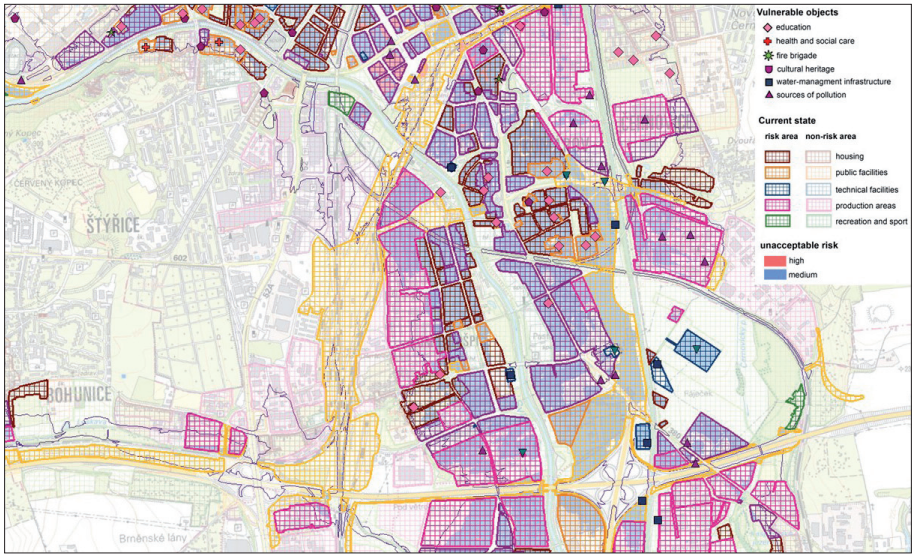


Fig. 3: An example of a flood risk map from Central Data Storage – Statutory city of Brno
Source: modified from Ministry of Environment of the Czech Republic (2021)

2.3.6 Opportunities and obligations for flood maps' utilization by the Czech (local) governments

Similarly to other European countries affected by floods at the turn of the millennium (for example, Poland, Germany), the need for a convergence of water management and spatial planning has been emphasized (Hegger et al., 2013); this has been reflected, among other things, in a stronger embedding of the use of flood tools such as flood maps by public administration/local governments.

Floodplain maps are binding for both spatial planning and water management activities, which follows directly from the Water Act; namely § 66 states that floodplain maps and their flood active zones are issued as Measures of a general nature[4]. Paragraph 67 of the Water Act lists binding restrictions in floodplains, for example, the prohibition of construction in flood active zones[5] or the competence of the water authority to set conditions for the use of floodplains outside flood active zones.

As the basis for setting restrictive conditions in floodplains serve, among others, the Flood risk management plans. Floodplains are also included among the so-called Land use limits[6] in the Planning analytical materials[7]. Limits are an indispensable basis for the creation of spatial planning documentation, although in the new legislation (Act No. 183/2006 Coll.) they are no longer part of the binding part of the Local plan. According to

[4] A measure of a general nature is a new type of decision-making by administrative authorities, introduced into the Czech legal system by Act No. 500/2004 Coll. In this administrative act, the subject matter is determined specifically, but the range of recipients is defined generally.

[5] Similarly, a building prohibition in the most risky areas is also set, for example, in France (Hegger et al., 2013).

[6] Land use limits create restrictions on changes/development in the territory due to the protection of public interests, resulting from legal regulations or resulting from the characteristics of the territory (§ 26 of Act No. 183/2006 Coll.). They set an insurmountable limit for the use and arrangement of the land.

[7] The Planning Analytical Materials contain the ascertainment and assessment of the state and development of the area, its values, programs for executing the changes in the area, ascertaining and assessing the area's sustainable development, and determination of problems for solution in the planning documentation (Tunka, 2010).

Macháčková (2018), "Planning analytical materials are a legally non-binding instrument of spatial planning, which has no binding external legal form, but at the same time, they are a very important basis for the acquisition and issuance of other spatial planning tools"; thus, they are always taken into account in the creation of the Local plan and other spatial documents. Planning decisions and building permits made by the building authorities must subsequently be in accordance with the spatial planning documentation (for example, Local plan).

Flood danger and flood risk are also among the Land use limits contained in the Planning analytic materials. The Spatial development policy of the Czech Republic in Article 12 prescribes "to define and protect development areas for the relocation of buildings from areas with a high risk of flood damage" (Ministry for Regional Development of the Czech Republic, 2023). For this reason, it is necessary to know the flood risk maps.

The legally binding nature of the flood hazard and danger maps is based on Decree No. 79/2018 Coll. These maps are a necessary basis for defining the active zone of floodplains, which are defined by Act No. 254/2001 Coll. The situation regarding the legal binding force of the flood risk maps is more complicated though since it is not directly defined in the legislation. The flood risk maps are part of Flood risk management plans, however, which are legally binding. The binding nature of the plans derives chiefly from the fact that they are issued by a Measure of a general nature and from § 23 of Act No. 254/2001 Coll., which states that "...the plans are the basis for the state administration, in particular for spatial planning and water management". The local authorities are obliged to evaluate each project in the given area individually and assess it in the light of the relevant Flood risk management plan (Záruba, 2022). One of the objectives of the Flood risk management plans is to prevent the emergence of new risks and to reduce the extent of areas at unacceptable risk. Knowledge of flood risk maps is essential for achieving this objective.

The above-mentioned legislation shows that the objective of the public interest in the Czech Republic is not only to increase the level of protection but also to move towards a multi-criteria flood risk assessment including, among others, efforts to assess the vulnerability of the area, and to mitigate the risk.

3. Materials and methods

Data were gathered by the Computer Assisted Web Interviewing (CAWI) online survey from the local government bodies/officials of all Czech Republic's statutory cities (in total 26 cities) in 2016; since parts of the territories of all of these cities belong to the Q100 flood zone (Fig. 4), it can be expected that activities, tasks, and decisions carried out by the respective bodies necessarily include those associated with floods and thus also with the use of flood maps (for example, building permits according to § 17 of the Water Act, setting the conditions for particular construction projects in flood zones, etc.). Furthermore, it can be reasonably expected as well that due to the spatial extent of the area under their administration, respective bodies are familiar with the territories covered by flood maps, and that they also possess sufficient technical equipment and personal capacities to enable adequate use and interpretation of flood maps, including the communication of the relevant information to various agents, such as other municipalities, levels of governance, or the public.

Through a combination of a pilot survey at the Municipality of Brno and the first author's professional experience with spatial data management and the creation of flood plans, particular departments within the local governments to be addressed by the survey were identified as those dealing with the issues of environment, water management, spatial and strategic planning, constructions, properties, and crisis management. The individual officials to be addressed were then further specified based on consultations with GIS (Geographic Information System) officials of the statutory cities, who, as managers of spatial databases, know precisely which job positions and individuals should use the flood maps.

The questionnaire used consisted of 10 questions (Tab. 2) regarding the flood maps and several identification questions (statutory city, department, job position, sex, age, and length of professional experience). As already mentioned in Section 2.3, data collection and analyses focused on three types of flood maps (floodplain maps, flood danger maps, and flood risk maps); flood hazard maps, despite their methodological importance, are not used as an independent source of information relevant for the decision-making of the statutory cities authorities and therefore

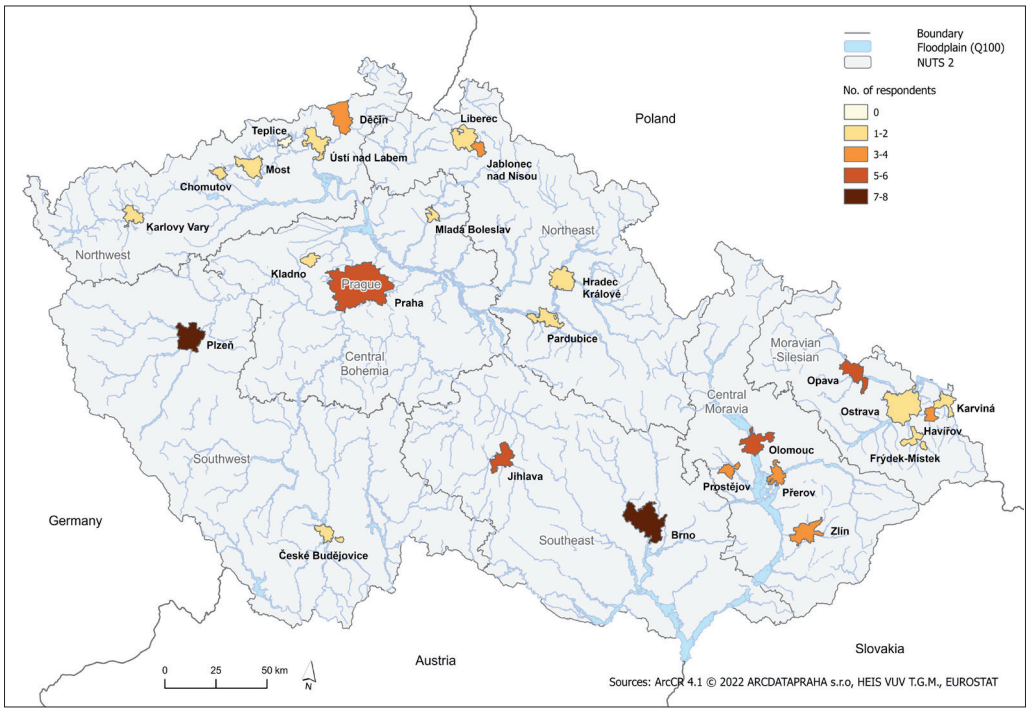


Fig. 4: Czech statutory cities addressed by the questionnaire survey
Source: authors' elaboration

Question No.	Question	Question type
Q1	Which flood maps do you use at your work?	closed
Q2	How often do you work with flood maps?/How often do you use flood maps?	closed
Q3	Do you use the Central Data Storage as a source of flood danger and risk maps?	semi-closed
Q4	If you do use the Central Data Storage, how would you assess working with it?	semi-closed
Q5	In the processes of spatial planning and decision-making, do you use flood maps or prefer to rely on your personal/professional experience?	semi-closed
Q6	How would you rate the sufficiency and availability of information about flood maps?	closed
Q7	How would you rate the flood maps according to the demands placed on you when interpreting and using them?	closed
Q8	Do you (or did you) take any further education on flood-related issues as part of conducting your profession?	semi-closed
Q9	Is there any data missing in your City's information system that you have to search for/acquire from other sources?	open
Q10	Are there any data you would add to the extant flood maps to aid the conduct of your professional tasks?	open

Tab. 2: Survey questions used in the study
Source: authors' survey

were not part of the data collection and analyses. The questions used to collect data were discussed and tested in cooperation with officials of the Brno City Municipality before being sent to all statutory cities.

The data gathered were analyzed using the methods of descriptive and inferential statistics; besides Cramer's coefficient and Spearman's rank correlation coefficient, non-parametric statistics were used as well, namely the Mann-Whitney U test, the Kruskal-Wallis test and Friedman's ANOVA.

4. Results

A total of 78 questionnaires were obtained from officials of 25 statutory cities (i.e. in one case only none of the city's officials responded). Table 3 shows the numbers of respondents by selected categories.

4.1 Utilization of flood maps (Q1)

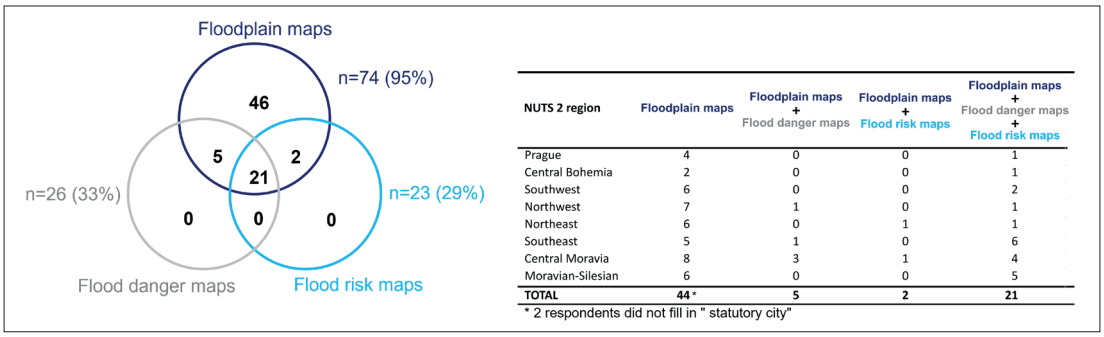
Particular types of flood maps are used unevenly (Fig. 5). A majority (95%) of respondents rely on the floodplain maps, while approximately one-third of them stated to use (also) other maps; combining all the maps took place in 27% of cases, and if two kinds of maps were used, floodplain maps were always one of them. Around 5% of respondents do not use flood maps at all.

The strongest association has been found between the number of flood maps in use and the department respondents work at (Cramer's V = 0.35). Almost 77% of spatial and strategic planning officials use more than one map (apart from them and the departments classified as 'other', respondents from no other department work with at least two types of flood maps in more than half of the cases). Thus, concerning the others, most of the respondents only use floodplain maps (these shares were approximately 54% in the Water management department, 64% in the Environment department, and nearly all of the respondents working at the Building offices). Another statistical association, although relatively weak (Spearman's coefficient − 0.18) was found between the usage of flood maps and length of professional experience, suggesting that the number of types of flood maps used increases with the length of the officials' professional careers. Our data (Spearman's coefficient 0.08) also suggest a certain role of the city size categories; it can be pointed out that officials from cities with more than 200 thousand inhabitants in more than half of the cases used all types of flood maps.

When considering the identification variables (Fig. 6), the relationship between the use of floodplain maps is strongest in the case of the department (Cramer's V = 0.27), but it is not statistically significant (almost everyone uses them). In contrast, the use of flood danger maps is related to both department (Cramer's V = 0.48) and length of experience (Spearman's rho = − 0.29). This means that the longer the respondent's experience, the less they use them. Figure 6 shows that these maps are used most by respondents with 6–10 years of experience. The use of flood risk maps is again associated with the department (Cramer's V = 0.47).

Department	**Water management**	**Environment**	**Spatial and strategic planning**	**Building office**	**Other**	**Unfilled**
	26	14	13	15	6	4
City size (number of inhabitants)	**0–50 000**	**50 001–100 000**	**101 000–200 000**	**> 200 000**		**Unfilled**
	18	28	14	15		3
Length of professional experience (years)	**0–5**	**6–10**	**11–20**	**21–30**	**> 30**	**Unfilled**
	7	15	28	15	4	9

Tab. 3: Number of respondents by selected categories (N = 78)
Source: authors' survey



NUTS 2 region	Floodplain maps	Floodplain maps + Flood danger maps	Floodplain maps + Flood risk maps	Floodplain maps + Flood danger maps + Flood risk maps
Prague	4	0	0	1
Central Bohemia	2	0	0	1
Southwest	6	0	0	2
Northwest	7	1	0	1
Northeast	6	0	1	1
Southeast	5	1	0	6
Central Moravia	8	3	1	4
Moravian-Silesian	6	0	0	5
TOTAL	44 *	5	2	21

* 2 respondents did not fill in " statutory city"

Fig. 5: Utilization of different types of flood maps by respondents (N = 78)
Source: authors' survey

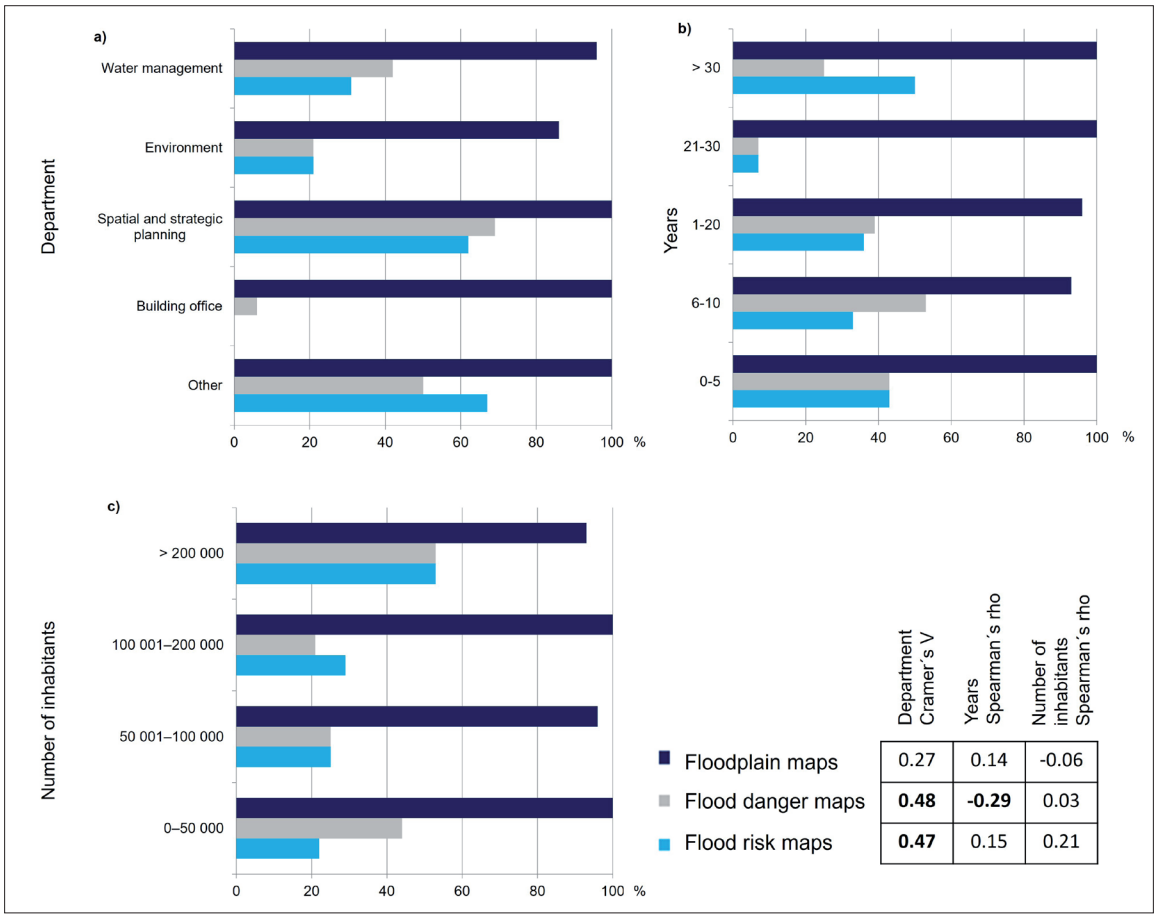


Fig. 6: The use of flood maps by respondents (%) according to (a) department; (b) length of professional experience; and (c) city size
Note: coefficients in bold are statistically significant at the α = 0.05 level of significance)
Source: authors' survey

4.2 Intensity and ways of using the flood maps (Q2, Q3, Q4, Q5)

The most frequently utilized were floodplain maps (at least once a week by more than 63% of respondents). The other maps are used much less frequently (Fig. 7).

For floodplain maps, an analysis was conducted to determine which groups of respondents utilize floodplain maps more frequently. At a significance level of $\alpha = 0.05$, the Kruskal-Wallis test was applied to test the hypothesis that the medians of the intensity of use of the floodplain maps by officials in each department were consistent. This hypothesis was rejected (p-value 0.005), with multiple comparisons revealing a difference between the officials of the Water management department on the one hand and the officials of the Spatial and strategic planning and the Building office on the other. The median intensity of floodplain maps utilization by Water management officials was equal to "daily", i.e. at least half of the Water management respondents use these maps on a daily basis (Fig. 8).

When conducting spatial planning and decision-making, 29% of respondents reported relying on flood maps rather than on personal/professional experience, while in 63% of cases they combined the two approaches. Regarding the source of the flood maps, only 15% of respondents stated to work with the official map portal, i.e. Central Data Storage (Ministry of Environment of the Czech Republic, c2021), wherefrom flood danger and flood risk maps are available. Within open commentaries, these respondents pointed out the portal's complicatedness, lack of clarity, and user-unfriendliness. The rest of the respondents use other flood map sources, primarily documentation of the river basin managers, municipal GIS, regional documentation, Planning analytic materials documents, etc.

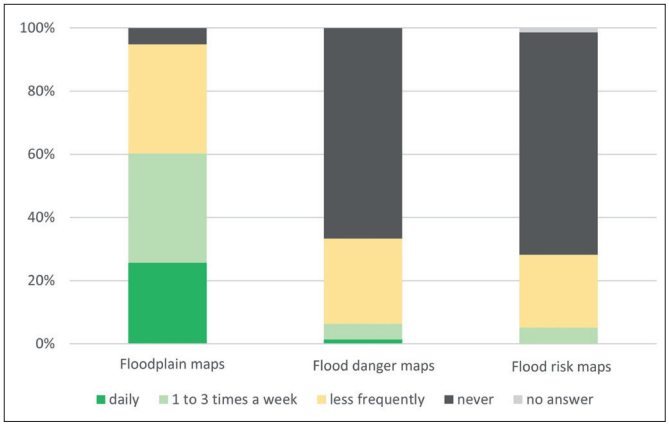


Fig. 7: Intensity of use of different types of flood maps by respondents
Source: authors' survey

4.3 Data in flood maps and their interpretation and usage (Q6, Q7, Q8)

Information on floodplain maps was sufficient and available for most (92%) of the floodplain map users, while information on flood danger and risk maps was considered insufficient and less available by around one-third of both their users and non-users (Fig. 9). There was no difference in median score values of information sufficiency between users and non-users for either type of flood map (Mann-Whitney U test p-value was greater than the $\alpha = 0.05$ significance level each time). If we did not separate the information sufficiency of each type of flood map, but evaluated respondents' answers among themselves, there was a clear difference in median information sufficiency scores among map types (Friedman's ANOVA p-value = 0.000).

Respondents' ratings of the ease of interpretation of individual flood maps varied considerably. The difference was demonstrated by Friedman's test (p-value = 0.000). Floodplain maps were viewed as the most easily interpretable and utilizable (Fig. 10). As regards flood danger and risk maps, their interpretation and usage were relatively more often considered challenging or complicated (24% and 17%, respectively).

More than half (55%) of the respondents stated to undertake further education on water/flood-related issues, mainly through workshops, seminars, and studying relevant documents. Cramer's coefficient (0.61) indicated a relatively strong association between further education and the respondent's department; Water management officials and respondents belonging to the category "other" took such training/education much more often.

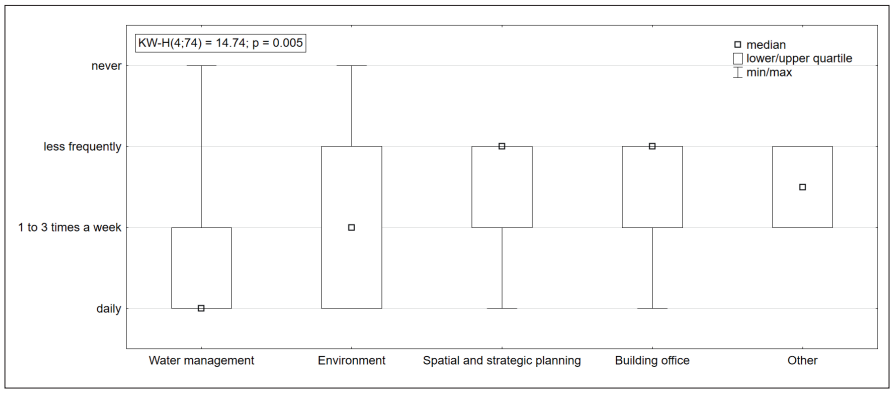


Fig. 8: Intensity of floodplain maps utilization by individual departments
Source: authors' survey

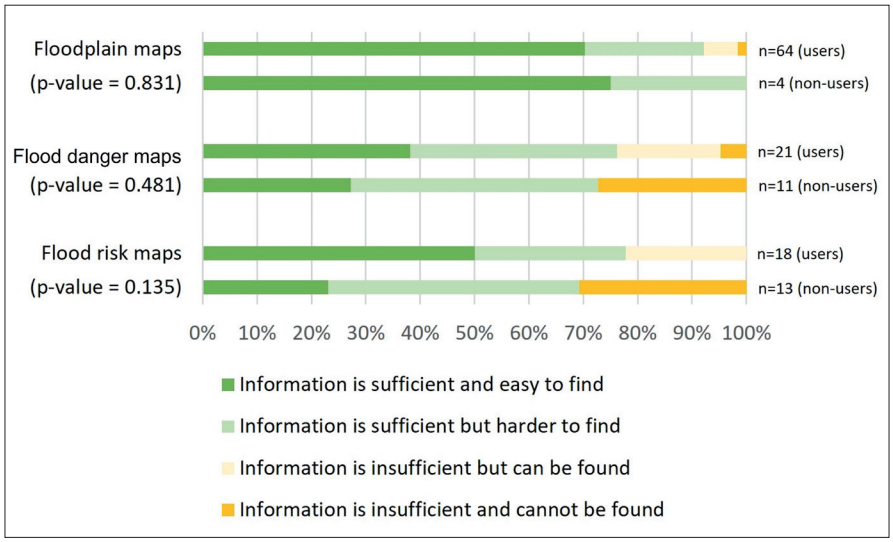


Fig. 9: Respondents' assessment of the sufficiency and availability of information on flood maps
Source: authors' survey

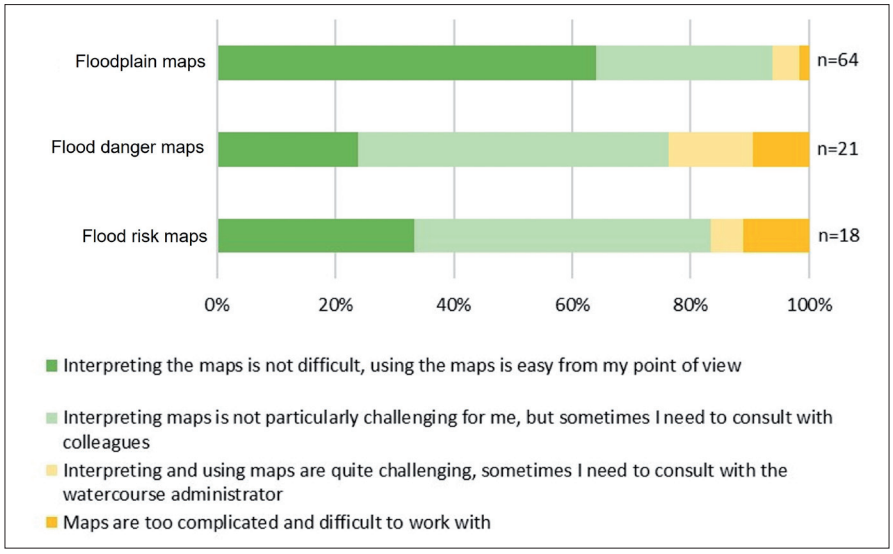


Fig. 10: Respondents' assessments of the difficulty of interpreting and using flood maps
Source: authors' survey

4.4 Suggestions for the flood maps adjustments (Q9, Q10)

Around one-third of respondents (30%) commented on the possibility of adding new data/information to the flood maps. Requests concerning any missing information were purely technical, including the addition of information on gauge curves, carrying out manipulations at water bodies, or construction activities in riverbeds. Only two respondents expressed a need for greater detail maps for working with specific parcels. None of the requests concerned the socio-economic data.

5. Discussion

Our data show that compared to other types of flood maps (flood danger and risk maps), local government bodies in the Czech Republic prevailingly rely on floodplain maps. Factors of a certain "tradition" can be at the game here, since these maps were for a long time almost the only flood map base (if leaving aside technical studies) available and used within relevant decision-making and planning processes (Section 2.2). Our results, however, also confirm that respective officials consider floodplain maps easier (or not particularly difficult) to interpret, and more than 60% of them regard information about these maps to be sufficient and available/easy to find. On the other hand, just less than one-third of officials use all three types of flood maps. In addition, even if the newer types of flood maps (i.e. flood danger and flood risk maps) are used, the intensity of their utilization is relatively low. In line with other authors (Andráško, 2021; Bera and Daněk, 2018; Fox-Rogers et al., 2016; Rauter et al., 2020), our findings thus confirm that despite certain developments already observed, the practices and processes of planning and policy/decision-making still largely neglect the up-to-date approaches and practices of flood risk management, including the multi-criteria risk assessment.

Hence, while flood maps have been recognized as one of the most important measures for improving public flood awareness and preparedness (Floods Directive, 2007), in the Czech Republic, but also elsewhere (Auliagisni et al., 2022; Meyer et al., 2012), they remain rather a technical information base than a risk communication instrument (*cf.* Maidl & Buchecker, 2015; Houston et al., 2019). This issue comes to the fore when considering our finding that flood danger and risk maps are used the least by Building office authorities. As stated in Section 2.3.1, Decree No. 79/2018 Coll. establishes the flood danger maps as a legally binding basis for the delimitation of active flood zones. Thus, Building office representatives should be those most aware of particular maps available and their contents to provide active, effective, and well-informed governance, including communicating the information on the methods and necessity of the active zones delineation (with pending restrictions on new construction) to the public (for example, to those applying for building permits). Notably, building and living in floodplains and active flood zones are particularly sensitive and important issues in many countries (Glosińska, 2014; Kongmuang et al., 2020), including the Czech Republic (Andráško et al., 2020; Hudson et al., 2022; Pechanec et al., 2011; Raška et al., 2018; Raška et al., 2022). On the positive side, our data also show that Spatial and strategic planning officials use the respective maps (i.e. the newer types – flood danger and flood risk maps) the most among all departments surveyed, which corresponds with recommendations on using flood maps in the formulation and evaluation of individual risk scenarios and adaptation strategies (Dottori et al., 2022). Our results, though, do not allow us to assess whether the utilization of flood danger and risk maps is not only a formal inclusion in the Planning analytic materials.

Another noteworthy finding our study brings is that almost a quarter of the officials working with flood danger and risk maps report that the interpretation of these maps' contents is challenging or even too difficult for them; this state of affairs is a bit surprising since more than a half of the respective officials also stated they regularly improve their flood risk management skills through some forms of further education (mostly seminars and workshops). Anyway, once the local government bodies are not well-versed in flood maps, it can be hardly expected that the lay public will do better (Albano et al., 2015; Kjellgren, 2013), a situation that definitely cannot aid the goal of making flood maps a vital part of more effective flood risk-related governance and communication (Auliagisni et al., 2022; Meyer et al., 2012).

Flood danger and flood risk maps are officially stored at the Central Data Storage (Ministry of Environment of the Czech Republic, c2021). Our findings however show that well less than a quarter of the respective officials use this storage; furthermore, it has been largely pointed out that the storage is user-unfriendly and too complicated to work with. For this reason, it seems appropriate and reasonable to integrate flood maps directly into web-based applications within the GIS systems of cities or any other levels of governance. Applications developed this way can also carry additional/supplementary information on flood risk and serve as a more appropriate risk communication tool (Albano et al., 2015; Maidl & Buchecker, 2015; Sanders et al., 2020).

Remarkable is also the finding that while flood maps are accepted by most officials as "helpers" for conducting their work tasks, in almost two-thirds of the cases they also combine them with one's own professional experience. This might not be seen as an issue at first glance. Such an experience however is usually tacit and non-transferable, a problem that aggravates in the light of situations associated, for example, with job/employment fluctuations/turnover, retirements, etc. Therefore, incorporating experience-related information from the officials into the flood maps is an essential, yet still underemphasized aspect of creating and utilizing flood maps (Auliagisni et al., 2022; Meyer et al., 2012). The same holds, however, also for the lay experience of the public; the potential for a better understanding of flood risk, making more competent decisions, and taking more effective actions by involving the personal experience of, for example, local inhabitants in the mapping process is then inevitably wasted (Sanders et al., 2020), with repercussions for the local communities' levels of risk awareness and flood preparedness/resilience (De Dominicis et al., 2015; Lechowska, 2018; Raška et al., 2018).

Considering the aspect of adjusting the extant flood maps, for example through supplementing them with any further information, we have found that only 2 of 78 officials addressed mentioned the additional spatial scales of the data displayed. The currently most used scale of 1:10 000 is, however, rather insufficient for decision making at the level of individual objects and small areas (*cf.* Porter & Demeritt, 2012); the fact that the flood maps are not customized to their primary users (Hagemeier-Klose & Wagner, 2009; Meyer et al., 2012; Sanders et al., 2020) may be one of the reasons (and hence explanations) why they are not used, for example, by the Building office representatives, as found by our survey. As regards any other additional data that the officials would consider useful to have in the flood maps, in general, these were primarily those associated with the hydrological and hydrogeological technicalities. The variety of individual responses (there were almost no overlappings in the stated requirements), however, points out the diversity and specifics of the positions using flood maps, and, at the same time, stresses the importance of taking the respective particularities into account when considering adjustments of the flood maps and their adaptations to the needs of the individual users (Mohanty & Simonovic, 2022). The observed complete absence of requests to supplement flood maps with socioeconomic information presumably suggests, once again, that the maps are not yet viewed as a tool for more complex, multi-criteria assessments and decision making (*cf.* McLaughlin, 2019;

Dottori et al., 2022), involving also the "human" or social aspects of the issues in question. Simultaneously, demands for only technical refinements of hydrological modelling outputs and technical data may indicate the overestimation of the accuracy of models applied and oversimplifications of the complexities of everyday reality, at least potentially leading to issues such as ineffective or even harmful decisions or interventions. Seipel and Lim (2017) then emphasize the need to include and visualize the respective uncertainties in flood-prone areas' delimitation.

6. Conclusions and suggestions for relevant research and practice

The paper presented the results of a study centred on whether and how local government bodies in the Czech Republic utilize particular types of flood maps within the processes of planning and decision/policy making. Results of a survey addressing the relevant officials from the Czech statutory cities showed that the earliest type of flood maps, i.e. the floodplain maps remain the most used, while the newer types, i.e. the flood danger and risk maps are utilized rarely. The mere inclusion of newer flood maps in national legislation thus seems to be an insufficient incentive for their more intensive use in the respective authorities' agendas. Furthermore, our findings suggest that flood risk management at the studied level of governance continues to stress the purely technical aspects of flood risk and flood protection, instead of promoting and applying integrated approaches incorporating, besides others, a multi-criteria risk assessment. This "inertia" thinking, and approach was confirmed also by the officials' suggestions for future improvements of the extant flood maps, involving solely their technical features and completely omitting any aspects and components of vulnerability or the social construction of risk. Unsurprisingly then, we found that the officials continue to use the flood maps only as technical tools, rather than (also) as a means of effective communication with other subjects/agents officially expected to be involved in managing the flood risk and dealing with flood events. The potential of more advanced flood risk management and improved flood resilience relying on multi-criteria assessment, the inclusion of a spectrum of agents (for example, local inhabitants) in the processes of policy/decision-making, and more effective cooperation, communication, and responsibility sharing, thus still represents a largely missed opportunity in the Czech statutory cities.

Except for contributing to closing the knowledge gap on the perception and utilization of flood maps by agents such as local government bodies, this study also suggests several avenues for future research and practice.

First, more needs to be known on the particular reasons for the underappreciation and underutilization of flood danger and flood risk maps at individual levels of governance. Because of their crucial role in information processing and interpretation, attention should also be paid to more intensive interfaces with GIS systems. Moreover, it seems appropriate to develop methodologies for adjusting the extant flood maps for the needs of target groups such as individual authorities/departments/job positions, potentially raising the interest and motivation to use the maps in the officials' everyday professional conduct. The processing of such customized maps could then be carried out by the GIS departments (assuming the availability of the necessary thematic spatial datasets), allowing for their regular updates and continuous development.

Second, the utilization of flood maps as a tool for fostering risk communication between individual levels of governance and agents such as the public needs to be not only more emphasized, but, especially, practised. To exemplify this requirement, there are more than 6,200 municipalities in the Czech Republic, and their representatives have to face and deal with an overwhelming number of frictions between various interests, and demands of numerous agents, not exceptionally associated with flood-related issues. Flood maps can be thus the means of supplying not only the representatives but also other agents (for example, residents) with the information needed in a relatively fast and sufficient way, allowing for more competent decisions, but also clear arguments for reconciliations of disputes and resolutions to dilemmas. Also at this point, an adaptation of the flood maps to the target groups (including the local inhabitants) seems to be an appropriate step, relying, first, on a methodology setting up a certain solid minimum of information every map must contain, and second, on the refinement and supplementation of these contents based on particular needs and demands in the areas in question. Therefore, the public is inevitably assumed to be involved in the identification of relevant data, provision of these data (for example, incorporation of the locals' flood memories, experience, practices, traditional measures taken in the past, etc.), and updates/maintenance of the final product (i.e. the customized flood maps). This way, not only the flood risk management in the area can be improved, but also the community's risk awareness, trust in the measures adopted, and willingness to participate in the numerous flood-related activities may be supported.

Third, funding for the flood maps' creation, updating, and maintenance is another issue to be (re)considered. The current praxis of relying on the state budget seems to be rigid, ineffective, and unsustainable. Drawing on the internal budgets for the GIS technologies development, already present and in use in the statutory cities and regions, may be an option here. In the cases of smaller municipalities, however, it will be necessary to find other ways of financing the preparation and maintenance of flood maps by external entities. Considering the pace at which data in flood maps become obsolete and need to be updated (and due to the climate change-associated challenges this pace will presumably speed up in the future), it seems reasonable to focus on the respective web applications, which are much more flexible and adjustments-friendly than their printed counterparts.

Fourth, for all the previously mentioned research and practice topics, it would be useful to focus in the future on a broader geographical area of European countries with similar public governance structures and flood management structures (for example, Poland, Slovakia, and others). Given the mandatory transposition of the European Directive into the national legislation of all EU countries, such research could provide a basis for obtaining best-practices in each of the studied thematic areas.

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