CORVINUS UNIVERSITY OF BUDAPEST
DOCTORAL SCHOOL OF BUSINESS AND MANAGEMENT

COLLECTION OF THESES

of the Ph.D. dissertation:

Gábor Ungvári

The role and potential of flood risk management in shaping land use

Flood-peak polders of the Tisza River from the perspective of integrated planning challenges.

Supervisors: Tamara Nóra Keszey PhD
Gabriella Szajkó PhD

Budapest, 2023

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I. TOPIC DELINEATION AND RESEARCH BACKGROUND

The water policy challenge in flood defense

Climate change is projected to make both water extremes (seasonal water shortages and surpluses – drought and flooding) both more severe and frequent (EC-JRC, 2020)., adaptation is needed to avoid or minimize the disruption of socioeconomic processes. (Kundzewicz *et al.*, 2002). At the same time, frustration is growing at the lack of implementation and the failure to find adequate, workable solutions to water-related issues (Biswas, 2004) (Woodhouse and Muller, 2017). "water failures" are not due to a lack of technological knowledge but are typically public policy failures (Pahl-Wostl and Kranz, 2010), (Woodhouse and Muller, 2017; Scholten, Hartmann and Spit, 2019). This realization was made clear in the OECD's report Principles on Water Governance (OECD, 2015).. The report attributes the cause of this phenomenon to the quality of the functioning of the so-called "meso-institutional layer." (Akhmouch, Clavreul and Glas, 2018) This is the institutional level where regulatory expectations from above, aimed at generating social benefits, clash with the interests of the groups that bear the cost of changes aimed at maintaining the status quo.

(Ménard, Jimenez and Tropp, 2018). The capability of this meso level of institutions is crucial in determining whether a frozen stalemate or workable rules emerge after the process of bargaining and enforcement. (World Bank, 2016).

The water policy challenge is characterized by the fact that, in the wake of new scientific discoveries, water links a wide range of stakeholders and interest groups in space and time, which should adopt standard sets of rules despite their cultural-, community-, and material differences of interest.

The policy field of defense against flood hazards faces these structural challenges that require a substantial upgrading of water governance skills. The floods of the 1990s and the turn of the millennium generated new questions. In many countries, research programs have identified the need to move forward because the solutions applied in the past will not be sufficient to deal with projected flood events. Proponents of a sustainability approach have started to promote the understanding that floods are natural events, cannot be avoided, and that protection systems will never provide full protection (Kundzewicz, 1999). To maintain the level of protection, it is necessary to intervene during the flood accumulation process and to adapt by reducing the value exposed to damage (Tollan, 2002). Among the strategies that use newer solutions, the Dutch program *Ruimte voor de River* ("Space for Rivers") has gained wider recognition

(Busscher, van den Brink and Verweij, 2019). Programs with a similar approach have been launched in several other countries and for various rivers, such as the Elba (Förster *et al.*, 2005; de Kok and Grossmann, 2010), Oder (Hudak *et al.*, 2018). In addition to the natural-hydrological questions associated with flood attenuation, results have been published that focus on the social conditions necessary for successful implementation (Aerts *et al.*, 2018; Otto, Hornberg and Thieken, 2018; Thaler *et al.*, 2018; Klijn *et al.*, 2021). (Hartmann, 2011) offers a conceptual overview of the process and defines the challenges. He concludes that if we want to create space for rivers, we need to reinterpret the approach to the management and maintenance of former floodplains. This challenge is also formulated by other authors (Roth and Winnubst, 2009; Rossano and Hobeica, 2014). The use of floodplains is confronted with complex social constructions through which and within which this process of making progress in flood risk management must take place.

Research background

The thesis is a synthesis of several applied research initiatives in which I have been involved in recent years. The below selection outlines the most significant components on which the thesis is based.

The EPI-Water FP7 research program between 2011-2013 provided the means for me – at the Water Economics Unit of the Regional Center for Energy Policy Research (REKK) – to deal with the topic of flood-peak polders along the Tisza River, the relationship between flood risk and land use, and the problem of their joint optimization in depth and to pursue our own economics-driven approach (*EPI-WATER*, 2013).

That research program laid the foundation for collaboration with the Middle Tisza Water Directorate aimed at exploring the economics of the operation of flood-peak polders under their auspices. This process culminated in R&D work (REKK, 2018) aimed at developing an operational management system for flood-peak polders on the Tisza and its tributaries. Further joint work was the collaboration in the "Danube Floodplain" Interreg Project (REKK, 2020)

Between 2017-2021 I participated in the LAND4FLOOD Cost Action program (Land4Flood, 2020). The aim of the program was to identify and systematize solutions to the problem of flood risk reduction on private land. The associated academic and practitioner community gave an inspiring background.

This is the professional embeddedness of my PhD work.

II. RESEARCH QUESTIONS AND THE METHODOLOGIES APPLIED

Research questions

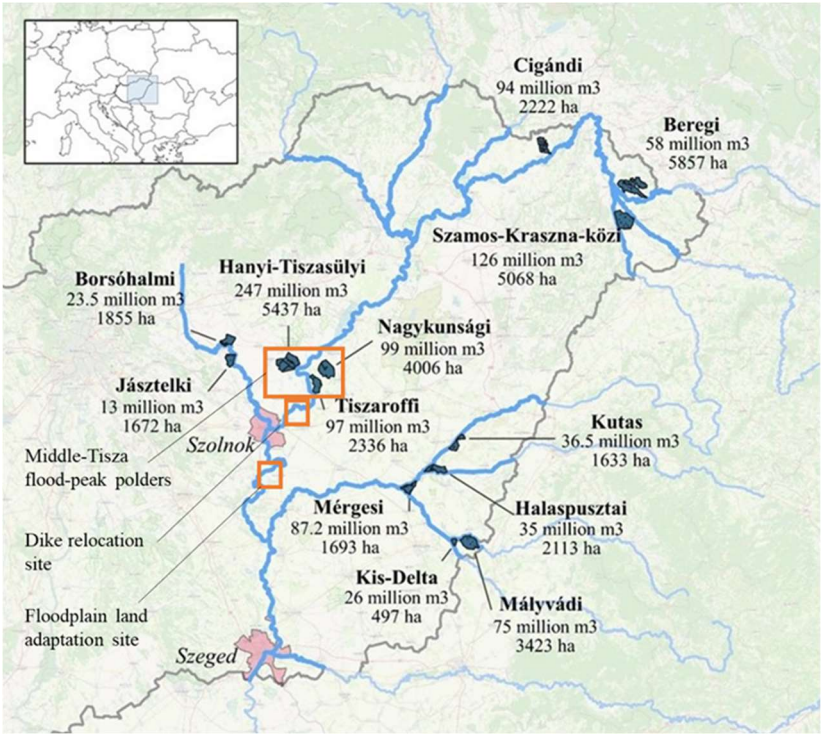
1, Based on experiences with the Tisza River, can methodological advances in flood risk assessment increase social welfare in the context of multi-purpose land use?

2, What improvements can economic instruments support, aided by advanced flood risk assessment methodologies, for initiating multi-purpose land use adaptation?

The background of cases investigated

The thesis focuses on the operation of flood-peak polders along the Tisza River and on issues associated with this empirical basis to explore the potential for adapting the land use of former floodplains.

Figure 1. Network of flood-peak polders along the Tisza and its tributaries



Legend: Map shows the flood polder system of the area and highlights the location of the study areas. Source: own figure.

The Further Development of the Vásárhely Plan (VTT), a complex flood protection and rural development program, was launched in the early 2000s. Since the first flood-peak polders were put into operation, new polders have been constructed. The evolution of flood simulation methodology between the design period of the VTT and the launch of the flood-peak polders'

operational management system in 2019 provides an opportunity to illustrate the role that economics can play in decision support.

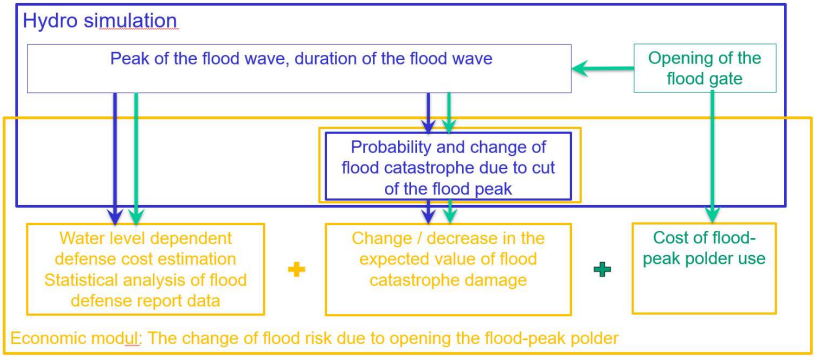
Another reason for the chosen territorial focus is that the VTT program and its implementation have not been extensively assessed in the literature besides their hydrological aspects. This can be seen as a success or a failure depending on the viewpoint of the sector. The analysis provides an opportunity to identify lessons for public policy implementation. Besides the cost-benefit analyses the thesis incorporates, the policy implementation process is analyzed through the lens of the spatial flood risk management approach. The Tisza River case is put into a broader context by comparing it with a Polish flood-peak polder implementation on the Warta River. The differences between the Hungarian and the Polish case highlight the nature of the undefined responsibilities and powers attached to land ownership and their consequences in forming spatial policies (Warachowska *et al.*, 2023).

Research methodologies

The thesis applies two methodologies to investigate flood risk reduction interventions and the policy conditions of their succesful implementation. A cost-benefit analysis methodology

has been used to demonstrate the impact of flood hazard reduction interventions, which includes the value of flood risk reduction among the benefits. A detailed discussion of the methodology development can be found in the first article of the thesis (Ungvári and Kis, 2022) that gave bases for the calculations for the Tisza River flood-peak polders' case.

Figure 2. Drivers behind the decision to open a flood-peak polder



Forrás: (REKK, 2018)

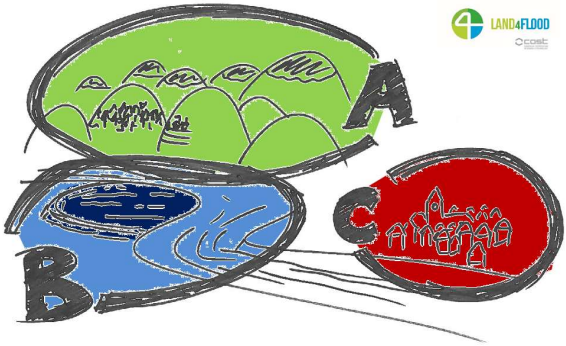
The application of the cost-benefit analysis methodology included the assessment of the damage/yield ratios of the areas used for flood risk reduction. The balance of the contribution of the land used was based on a combined analysis of several land use and flood risk reduction scenarios (Ungvári, 2022).

I examined flood risk reduction measures requiring the inclusion of additional land as a policy implementation process using the Spatial Flood Risk Management approach to identify

implementation problems and explore the conditions necessary to develop multi-functional land-use agreements that provide higher overall social benefits.

Spatial Flood Risk Management is an innovative approach that intends to address these challenges by using new developments.(Hartmann, Slavíková and McCarthy, 2019; Hartmann, Slavíková and Wilkinson, 2022). It provides a coherent structure for the respective issues and tools in line with the logic of policymaking, focusing on the additional land needed for flood-risk reduction.

Figure 3. Focal points of intervention in the river basin



A	Hinterland - retention and attenuation
B	Flood storage and Room for the river
C	Resilient cities (adapted urban areas)

Source: Adapted from (Hartmann, 2022) Figure 1.2

The advanced risk assessment and conceptual approach reinforce and presuppose each other's existence, as cross-

sectoral coordination requires comparing the costs and benefits the quantitative method identifies.

Although how to calculate flood risk has long been theoretically clear (the flood damage event multiplied by the probability of occurrence), in practical terms, it has always reflected the information-processing capabilities of the time and has evolved with these capabilities. The evolution of simulation technologies in the field of water damage prevention over recent decades can be identified in the move from qualitative flood risk assessment methodology to quantitative flood risk assessment. (Scorzini and Leopardi, 2017).

The new methodology simulates the impact of the interventions on flood wave accumulation at high resolution and catchment scale; this involves considering many components (micro-relief, soil type, roughness, and infiltration factors). The same change is true of the components affecting damage (depth of inundation, duration, velocity of water flow, etc.) in the area exposed to flooding (European Commission. Joint Research Centre., 2016; Huizinga, De Moel and Szewczyk, 2017).

The advancement in and importance of quantitative flood risk calculations to the applicability of economic methodologies can be seen in the fact that it is now possible to make cost-benefit comparisons instead of applying cost-effectiveness or cost-minimizing approaches.

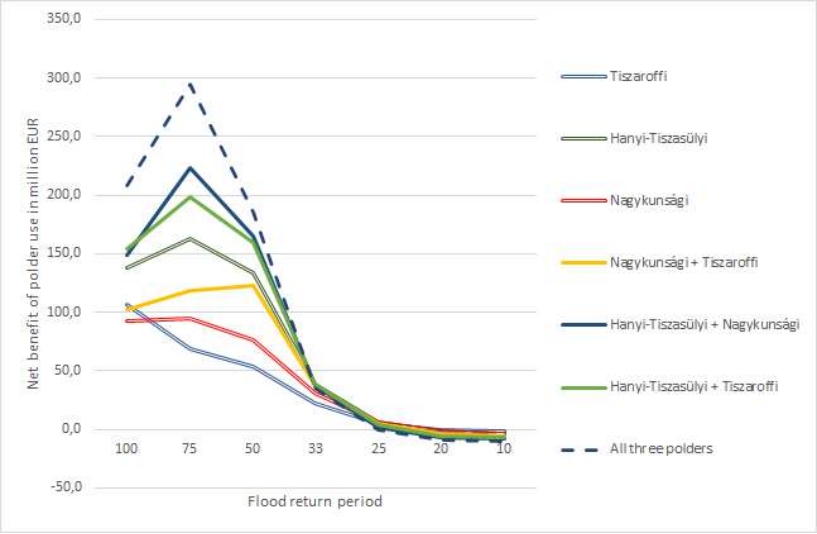
This technological change not only allows for more accurate information-based decision support in the field of flood risk management but also opens the door to new possibilities for application in the sense of connecting landowners (service providers), whose land use adaptation can results in flood risk reduction, with beneficiary groups of the change. (Thaler, Priest and Fuchs, 2016). (Kerr, 2007) expected such technological advances to aid reaching improved safety level in watershed-scale using the organizational context of managing flood risk as a landscape wide "common pool resource".

The synthesis text of the dissertation provides recommendations for a more effective integration of the cost-benefit analysis toolkit and its further use in the Spatial Flood Risk Management context.

III. RESULTS

Flood-peak polders on the Tisza River were created to attenuate the very rare, extreme flood waves that can cause catastrophic flooding if dikes are overtopped. However, when flood-peak polders are examined using a quantified risk assessment methodology and a cost-benefit approach, the use (opening) of flood-peak polders for a much more comprehensive range of flood events can be justified. This contribution is the central message of the first article of this thesis and provides an approving answer to my first research question (*Based on experiences with the Tisza River, can methodological advances in flood risk assessment increase social welfare in the context of multi-purpose land use?)*

Figure 4. Flood-peak polders' net benefit over different return period flood events



Source: (REKK, 2018)

Cutting the peak of flood waves between the economic break-even point flood level and the designated level of opening due to flooding based on physical parameters increase social well-being. In Figure 4 the additional benefit of a polder's use is represented by the area beneath the subsequent curves. For polders along the Tisza, the economic break-even point is within the range of 20-40 year return frequency floods compared to the planned 100-year return frequency (Ungvári & Kis, 2022b).

The optimal solution can be created by integrating into one system the effective flood-risk reduction benefits that can be achieved through controlled inundation and the non-flood-risk-

reduction type benefits. The first article (Ungvári and Kis, 2022) indicates that this condition cannot be met based on flood-risk reduction benefits alone.

The calculations presented in the second article (Ungvári, 2022) show that this condition can be met, but requires a higher level of spatial planning and stakeholder coordination capabilities than the current practice provides. Answer to the 2nd research question (*What improvements can economic instruments support, aided by advanced flood risk assessment methodologies, for initiating multi-purpose land use adaptation?*) explores this terrain, where quantified flood risk management methodology can aid cost benefit calculations to structure relations on the watershed for using economic approaches and instruments to enhance the effectiveness of policy implementation. As the synthesis text describes achieving water policy goals is frequently mired with failures. What is lacking for a successful implementation can be described as the effective functioning of the meso-institutional layer identified in the OECD assessment (Akhmouch, Clavreul and Glas, 2018). This is what the Spatial Flood Risk Management approach aims to achieve in the field of policy or social innovation as the third article contextualize the challenge (Warachowska *et al.*, 2023).

The construction and commissioning of the Tisza flood-peak polders were the first components of spatial flood protection in

Hungary. As a result of the VTT development program, flood risk along the Tisza has been significantly reduced. However, the level of well-being thus improved falls short of the potential associated with this initiative. The Spatial Flood Risk Management approach and the international experience with flood-peak polders suggest that it is more appropriate to look at the current situation of the VTT development program as a stage in a process in which further welfare gains depend on the ability to link the service provider (cost bearer) and the beneficiary groups. A higher level of well-being can be expected from combining multilateral agreements on using additional land for flood management. The challenge is whether a system of agreements and rules can be established to enable decisions and the reconciliation of interests in land use adaptation and whether financial transfer mechanisms can be set up for this purpose (that all together embody a functioning meso-institutional layer). The Spatial Flood Risk Management framework as a policy implementation roadmap can be used to support such regulation-making activities. In this approach, the method of quantified flood-risk assessment plays a key role, as it can help define the link between actors in different locations and sectors in the river basin using economic terms.

However, filling the gaps in the effective operation of the meso-institutional layer in question stretches the boundaries of water

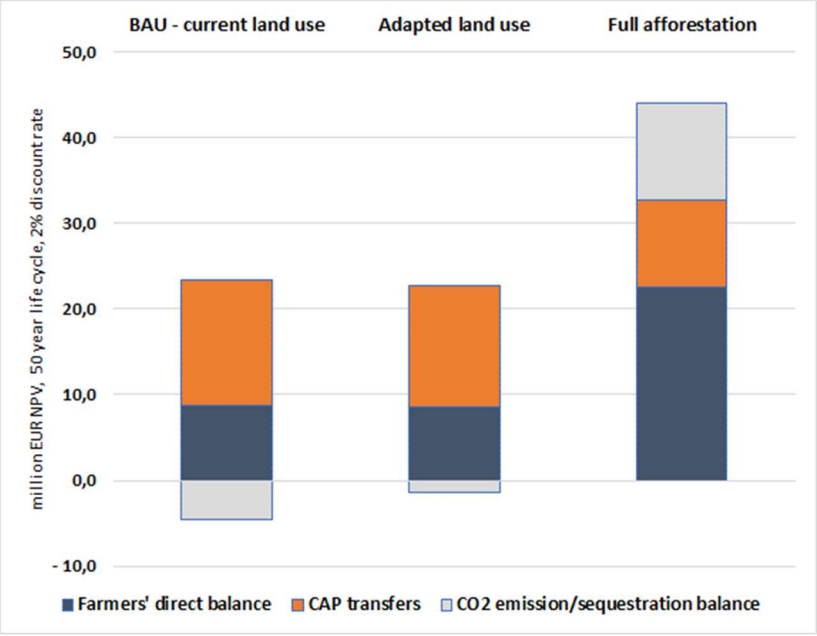
governance systems. In aiming at the implementation of nature-based solutions, an improvement in the perspective of participants' roles is necessary. There must be a shift from state/municipal organizations viewing themselves as executors and stakeholders as users or passive adopters of measures to state entities acting more like managers and regulators of cooperation platforms and stakeholder groups being considered providers and beneficiaries of many of the services governed and negotiated according to the rules of the platform. This shift in attitude may make the difference in successfully implementing spatial or nature-based flood risk management solutions. The evaluation of VTT development in the thesis sheds light on this differentiation, as it was assessed according to the underlying organizational conditions using the Spatial Flood Risk Management approach.

Watershed service providers' willingness to participate in such schemes is strongly connected to their expectations about future land utilization. Providers of nature-based solutions must remain active managers of their resources and must be able to develop their economic positions.

The public has a significant interest in the benefits that can be made available through afforestation in former floodplain areas. This interest is attached to both flood-risk reduction and carbon sequestration. The same cannot be said of landowners; for them,

there is no afforestation trajectory whereby a desire to increase productivity coincides with an increase in long-term carbon sequestration and forest management revenue. This situation poses an obstacle to upscaling in relation to additional private areas that can be permanently and robustly managed for flood attenuation benefits.

Figure 5. Individual and public benefits by the land use scenarios in the Cibakháza floodplain area.



Source: own figure

If the size of the benefit can be quantified, the question is how it should be allocated between landowners and the public to

encourage implementation. Rather than subsidies, marketisation of the carbon sequestration capacity of the floodplain forests to be created during land use adaptation could be one way to attract the interest of landowners. Calculations have shown that, at present, the settlement of this benefit element would have the most significant impact on the financial balance of landowners.

What must be highlighted here is that the accountability for carbon sequestration as a benefit currently falls entirely on the state. Does this mean that the expropriation of the carbon content of forests by the state is currently the greatest obstacle to opening up space for water in the floodplain?

The linking of property-rights issues related to afforestation on privately owned floodplain areas with flood-risk management is a logical extension of the Spatial Flood Risk Management approach. However, the much broader ecosystem service potential of floodplain forests suggests that this spatial management approach, based on the logic applied to flooding, can play a pivotal role in managing the other water extreme, drought, as well as nature-based solutions to drought begins with flooding (private) land suitable for infiltrating water.

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V. MOST IMPORTANT OWN PUBLICATIONS ON THIS TOPIC

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