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Prioritising water-related regional development project ideas based on stakeholder involvement activities: A case study from Szigetköz, Hungary

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ABSTRACT

Szigetköz—a large island of the Danube in Hungary—is attracting a new wave of interest in water-related regional development projects from the public and private sectors alike. The revived interest in the Szigetköz floodplain area, which has historically endured the adverse effects of large-scale water management initiatives, draws attention to the necessity for careful consideration and the active involvement of local stakeholders in the decision-making process.

In our research, we conducted various stakeholder engagement activities, including interviews, questionnaires, and workshops. These activities helped define the problems and objectives of each stakeholder group. Through collaborative consultations, we gathered over 100 proposed water related development project ideas. Additionally, to address key issues in project development and selection, we evaluated the integrative potential of each proposed project, considering the number of distinct water management issues it addressed. We also assigned an attitude score to each project, derived from the diverse objectives of various stakeholder groups, and analysed these quantities using a multiple-criteria analysis.

This paper details a novel approach to assess and rank the proposed water-related regional development project ideas based on the calculated integrative potential and attitude scores. The goal was to prioritise and further develop these proposed projects to benefit Szigetköz and its surrounding areas.

Main results of the study have shown the average project scored between 0.33–0.50 in integrative potential out of a maximum of 1.00 For positive attitude score the average was between 0.28–0.43, out of a maximum of 1.00 while for the negative attitude score the average project scored between -0.14–0.00 out of a minimum of -1.00.

The ranking of projects that was based on these scores, highlighted three types of proposed projects that need to be further developed in different ways. The top-ranked positive attitude integrative projects need cost-benefit calculations involving all ecosystem services to justify their economic sustainability. Top-ranked opposing attitude integrative projects need conflict resolution to be socially sustainable. Finally, project ideas that scored low on integrative potential need to be developed to make use of blue-green infrastructure, and circular economical advancements to foster their environmental sustainability.

1. Introduction

The Danube is the second longest river in Europe, crossing 19 countries as it meanders from its source to the sea. The Danube's catchment area is 807,827 km^2, with more than 80 million inhabitants (Habersack et al., 2016). It is one of the best-known rivers in the world (Funk et al., 2019). The floodplains of the Danube provide a wide variety of ecosystem services that ensure their proper and healthy functioning, support biological diversity, and provide natural flood protection (Serra-Llobet et al., 2022). These areas are outstandingly fertile (Clilverd et al., 2022), store water, bind CO_2 (Lawson et al., 2018), and supply drinking water for millions (Schwarz, 2010). Floodplain ecosystems are resilient to ecological disturbances (Cottingham et al., 2005). However, they are endangered (Fryirs and Brierley, 2016) due to extensive human development, including urbanisation, pollution, (Petsch et al., 2023) widespread agriculture (Mosner et al., 2015), and hydropower generation (Chukwuka and Adeogun, 2023).

An outstanding example of this high degree of floodplain

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vulnerability can be observed in the middle section of the Danube River, downstream of the Austrian-Slovakian-Hungarian triple border, in the form of the Gabčíkovo-Nagymaros water management Project (Smith et al., 2000). This project culminated in diverting 80 % of the Danube in 1992 toward an artificial supply channel for the Gabčíkovo Hydropower Plant (HPP) (Smith et al., 2002). Without the Nagymaros Dam, the intervention had a long-lasting environmental and social effect on the floodplains of Szigetköz, a large, populated, agriculturally cultivated island in the Danube in Northwestern Hungary (Zsuffa et al., 2023). As a result of the diversions, the floodplain river branches lost connection with the main river and ran completely dry. Additionally, low water levels in the Old Danube (main riverbed) also drained the near-surface groundwater system lowering the water table by about 1.5 m in some areas (Bárdossy and Molnár, 2004).

After the severe environmental consequences of the diversion of the Danube, the main goal of local water management interventions was to offset the adverse effects of past water management actions. Stakeholder involvement played a crucial role in planning countermeasures. All organizations cooperating in the restoration effort believed that returning to the characteristic surface and subsurface water levels observed in the reference period of the 1950s would help maintain the natural ecosystem and water-based economic activities in the area (Láng and Dunai, 2000). Water replenishment systems were constructed in several stages over the past 30 years to facilitate this increase in water levels. These river and floodplain rehabilitation and restoration projects throughout the Szigetköz region have markedly diminished the harmful effects of earlier water management efforts and enhanced the ecosystem and biodiversity of the Danube floodplains (Jakus et al., 2024). Due to these endeavours, the surface and groundwater levels in the floodplain area around Szigetköz partially recovered to their original levels.

Floodplain restoration has fostered investment in additional water-related regional development projects from the public and private sectors (Kézai et al., 2022). Given this growing interest in floodplain development in an area that suffered significantly from failed water management interventions, adopting a systematic approach to project development is essential. In addition to traditional engineering design, careful consideration and involvement of local stakeholders in the decision-making process are necessary.

In this paper, the researchers present a case study of project prioritisation that builds heavily on stakeholder involvement. The article highlights the results of interviews, questionnaires, and workshops carried out across Szigetköz over nine months. During this time, the authors collected, evaluated, and prioritised more than 100 water-related project ideas. Therefore, the paper also introduces a novel approach to assessing and ranking these project proposals, focusing on developing environmentally, socially, and economically sustainable solutions.

2. Literature review

Floodplain development must occur holistically to achieve a valuable and desirable final condition. According to Schindler et al. (Schindler et al., 2016), development projects that respect the balance between human needs and environmental preservation offer a win-win scenario for all stakeholders. As Palmer et al. (Palmer and Filoso, 2009) and Schindler et al. (Schindler et al., 2014) established, floodplain developments can yield extensive social benefits when thoughtfully planned and implemented. These benefits include flood prevention, land use, and management, which extend to broader societal and economic gains (Basak et al., 2021).

2.1. Overview

Erős et al. (Erős et al., 2019) performed a meta-analysis of peer-reviewed literature concerning restorations in large floodplain rivers worldwide. They examined methods to assess ecological conditions, the degree of landscape alteration, the spatial scale of the study, and the breadth of rehabilitation. They found that many studies suffered from a narrow scope. The use of biotic indexes, structure of biotic assemblages, land use, and other indicators demonstrated various approaches and assessment tools. They emphasised the need for holistic indicators and assessment schemes for ecological condition evaluation.

A large number of floodplain developments have affected the Danube River. Funk et al. (Funk et al., 2019) assessed these impacts using a multi-functional approach with various indicators. Evaluating a floodplain development project for its potential to serve multiple functions is standard; however, broad-scale pre-assessment and prioritising stakeholder-generated project ideas – as presented in this study – is not yet typical. In many recent developments, stakeholders initiated the projects; thus, they invested time and resources to ensure their success, as noted in research by Halbe et al. (Halbe et al., 2018). With public involvement and participatory actions, the approach changes from top-down to bottom-up, leveraging knowledge transformation (Graversgaard et al., 2017) and increasing public awareness.

On the other hand, the bottom-up collection of numerous full-scale project ideas and the ranking of this multitude of project ideas based on their ability to serve multiple functions is still novel. This study implements a universal and forward-thinking approach to this problem with multi-functional prioritisation.

2.2. Multi-function approach

Adopting a multi-functional approach to project selection and development is essential (Anon., United Nations World Water Assessment Programme 2018). In practice, a *multi-functional approach* means that when projects are selected and developed, they serve multiple functions or benefits simultaneously (Cumming et al., 2015). For example, a water management project in a rural area might aim to prevent flooding, restore habitats, and use excess water for irrigation. This approach integrates existing uses, applications, and emerging needs (Eder et al., 2022). Integrating existing uses involves recognising and incorporating how the community utilises a space or resource. Such integration might include traditional farming practices, local recreational activities, or existing wildlife habitats (Sommer et al., 2020). In application, a multi-functional approach incorporates innovative methods that can serve multiple purposes. For instance, green infrastructure in rural planning can manage stormwater, create buffer zones and other ecological zones and wetlands, revive ecologic corridors, and mitigate soil erosion (Hindersah et al., 2020). Emerging needs include climate change mitigation and adaptation (Skidmore and Wheaton, 2022), energy efficiency, digital connectivity (Hoolohan et al., 2018), and social equity.

Selecting the most appropriate projects from various options and suggestions is complex. Stakeholders often express conflicting desires (Wam et al., 2016), applying different information processes and prioritisation techniques (Bahadorestani et al., 2020), resulting in multiple (and sometimes contradictory) solutions. Therefore, it is vital to develop methods that help rank project ideas and select sustainable projects with broad support or the fewest counter-interests (Bahadorestani et al., 2020). When gathering development needs and ideas, planners should involve the broadest range of stakeholders (King et al., 2015). Once gathered, planners pre-categorise and prioritise project ideas (Wolfson et al., 2020) to achieve socially, environmentally, and economically sustainable development with the least conflict (Schneider and Buser, 2018).

When selecting and developing multi-functional projects that align with the criteria of sustainability and stakeholder benefits, decision-makers face two primary challenges:

(1) Managing Increasing Conflicts of Interest: Multi-functional projects bring together various stakeholders, each with unique interests and priorities. This diversity often results in conflicting interests (Mishra et al., 2021), making it challenging to find solutions that satisfy all

parties.

(2) Filling Knowledge Gaps: Seeking out all relevant stakeholders can be difficult in itself. However, understanding these stakeholder groups' specific objectives and concerns (Kumar et al., 2021) and communicating them to other groups poses an even more significant challenge.

Given these challenges, the involvement of stakeholders in the preparation, decision-making, and implementation phases of such projects is critical, as Morrison (Morrison, 2003) emphasized. This involvement is crucial because of the long-term impacts of these developments, and, as Vijulie et al. (Vijulie et al., 2019) noted, it also accounts for the multidisciplinary aspects and the evolving nature of stakeholder interests and demands.

Stakeholder involvement activities have become a staple in the water resources management sector to address these issues (Nandalal and Simonovic, 2003). Recent research underscores the effectiveness of stakeholder participation in enhancing project outcomes. For instance, Ben-Daoud et al. (Ben-Daoud et al., 2021) demonstrate how stakeholder involvement can help evaluate management systems' integrativeness (degree of integration). Similarly, Heikoop et al. (Heikoop et al., 2023) highlight its role in defining the issues and objectives of stakeholder groups. Worley et al. (Worley et al., 2023) discuss its utility in ensuring projects align with multiple stakeholder objectives, while Olofsson et al. (Olofsson et al., 2023) show its effectiveness in resolving conflicting interests. Additionally, Demetropoulou et al. (Demetropoulou et al., 2019) illustrate how stakeholder participation can aid in proposing and prioritising water-related measures within a basin.

Stakeholder contribution enabled the local communities in Szigetköz to work together successfully to replenish and rehabilitate their floodplain habitat in the past, however these activities need to be continued and further developed in the face of the present wave of interest towards water related development ideas in the region.

2.3. Stakeholder participation

Various participatory techniques (Stosch et al., 2022) — each offering different levels of stakeholder involvement — can be applied to engage stakeholders effectively in the project development process (Luyet et al., 2012). The selection of the most appropriate technique depends upon the characteristics of the stakeholders involved and the specific challenges or opportunities presented by the project.

Participatory workshops have emerged as a particularly effective method for capturing the objectives and concerns of stakeholders (Anon., OECD 2015). These interactive sessions provide open dialogue and collaboration, allowing diverse groups to contribute their perspectives and insights. Similarly, structured interviews with local decision-makers and targeted surveys of private sector participants are formal methods that can uncover a wide range of potential measures or developmental ideas, offering a more nuanced understanding of stakeholder expectations and needs (Wehn et al., 2018).

A carefully designed and implemented stakeholder activity brings together a large, diverse, often contradictory data set. In order to turn data into knowledge (Gregory, 2000), the results of stakeholder involvement activities need an information processing methodology (Fonseca et al., 2023). This methodology must allow for transparent data organization that enables grouping comparable data around specific areas and topics to form well-defined project ideas. A ranking system is also essential to compare the project ideas identified. The ranking system will highlight those projects with environmental impacts and socially significant developments for further and more detailed planning. Multi-criteria analysis (MCA) has become a valuable tool for evaluating and prioritising diverse project proposals as demonstrated by Demetropoulou et al. (Demetropoulou et al., 2019), and Maurya et al. (Maurya et al., 2020).

2.4. Multi-criteria analysis

MCA facilitates a structured comparison of proposed projects against a predefined set of criteria reflective of the project's objectives and the stakeholders' values. Most stakeholders' ideas and needs are qualitative rather than quantitative; therefore, it is essential to transform the descriptive data into numbers (Bagstad et al., 2013). By converting complex, often qualitative information into a quantifiable performance measure, MCA enables decision-makers to objectively assess each proposal's merits. The weighting within the MCA process plays a critical role (Huang et al., 2011), as it quantifies the relative importance of each criterion, ensuring that the prioritisation of projects aligns with the overarching goals and stakeholder preferences. When the weights of the different criteria are identical (Odu, 2019), MCA produces an approximate, general solution. However, varying the weights and examining the sensitivity of the criteria can provide additional information for more accurate results. For a deeper assessment of environmental-social results and better understanding and prioritising them, changing the weights can refine the results and highlight the most significant sustainable developments.

Prioritising project ideas, especially complex ones, necessitates a multi-criteria approach to ensure a comprehensive evaluation and selection process. The study presented in this paper adopted a case-study approach and aimed at creating an innovative framework for project prioritisation. The core objective of this paper is to methodically assess and rank the proposed water-related regional development projects through the lens of MCA. This analytical process leverages the projects' integrative potential and attitude scores as foundational criteria for analysing the number of involved water-related issues and stakeholders' attitudes towards each project. By doing so, the paper identifies and prioritises project ideas that exhibit a high potential to address multiple water management issues and align with the broader objectives and expectations of the stakeholder community. The novelty of the evaluation is that it combines the two analytical approaches—integrative potential and attitude scoring—and evaluates projects in a combined multi-dimensional social-environment-economy space. In addition to examining positive (*rather supported*) projects, it strongly emphasises examining negative (*rather opposed*) projects. Ultimately, this prioritisation seeks to guide decision-makers in advancing the most promising projects, thereby contributing to the sustainable development of floodplain areas through a collaborative, stakeholder-informed approach. In contrast, the most confrontation-provoking and controversial projects are analysed to seek to understand the opposing interests and find reasonable compromises at an early stage of project development.

Authors undertook extensive stakeholder consultation efforts during the research, which yielded over 100 proposed project ideas. Recognising the complexity inherent in project development and selection, the integrative potential of these proposals was investigated. This assessment examined how each project addressed various water management challenges, gauging its capacity to address multifaceted environmental and societal needs. Furthermore, attitude scores were assigned to each project proposal to capture stakeholder groups' diverse perspectives and objectives. This score quantified the level of support or opposition each project might encounter based on the stakeholders' priorities.

2.5. Site Description

The Danube transitions from the swift channels of the Alps and the Carpathian Mountains near Bratislava, Slovakia, to a slower, broader channel with a reduced gradient near Szigetköz. The river deposits sediment, creating countless islands in an intertwined river branch system, commonly called an inland delta (Dr. Göcsei, 1979). Hungarian river regulators shaped the main riverbed (Old Danube) in the 19th century. Today, the riverbed marks the border between Hungary and Slovakia. The Mosoni-Danube forms the southernmost branch of the Danube in this network. The area between these two Danubes is called

Szigetköz (German: *Kleine Schüttinsel*, Slovak: *Maly Žitný Ostrov*). Szigetköz is Hungary's largest island, with a land area of about 375 km^2. There is a vast island on the Slovakian side as well, called Csallóköz (Große Schüttinsel/Žitný Ostrov); however, it is not the focus of this study. An overview map of the Szigetköz area's main features appears in Fig. 1.

Large-scale water management projects significantly reshaped the area, first with river regulations, then with flood-protection levees, and finally with the construction of the Gabčíkovo Hydropower Plant. After the severe environmental consequences of the Gabčíkovo diversion, water managers constructed replenishment systems in several stages in the active and historical floodplain. As a result of the above interventions, the tangled web of once interconnected Danube branches became a heavily fragmented system at Szigetköz (see Fig. 2).

2.5.1. Szigetköz today

Today, the Island of Szigetköz contains active and historical floodplain areas. The active floodplain is fragmented with several river branches. The islands between branches are covered mainly with natural floodplain forests and poplar plantations.

The historical floodplain of Szigetköz—surrounded by flood protection levees—is a composite landscape with various land uses. The most significant part is agricultural, typically arable land. There are smaller amounts of meadows and pastures. Thin forest strips, canals, oxbow lakes, swamps, reeds, and other wetlands form the landscape's edges.

More than 20 settlements are located in the historical floodplain of Szigetköz. Győr and Mosonmagyaróvár account for over 80 % of the region's population. Smaller settlements in Szigetköz have grown noticeably in recent decades, but the population density is still below the national average. The commuting population moving out of the big cities significantly contributes to this increase.

The community of Szigetköz has always relied on the Danube and its numerous side branches to supply necessary resources. Historically, fishing, hunting, and forestry were the main means of livelihood in the floodplain areas. After river regulations and the building of flood protection levees, agriculture became predominant in the historical floodplain, relying on favourable soil and climatic conditions. In the past 20 years, eco-tourism, relying on floodplain restoration activities, has been the most rapidly emerging sector for the settlements of Szigetköz; however, its tourism infrastructure (hotels, restaurants, attractions) has significant deficiencies. (Kézai et al., 2022)

2.5.2. Szigetköz operating committee, HFWRS

A distinguished event in the history of the Szigetköz community was the establishment of the Szigetköz Operating Committee in 2001. The Committee began during the restoration efforts to reconcile stakeholder interests and oversee the planning and operation of water replenishment systems. The members of the Committee represent various sectors such as water management and water damage prevention, nature conservation, forestry, agriculture, local government, fishing, and tourism organizations. The Committee meets at least once a year in a General Assembly to negotiate current issues and discuss plans.

This paper investigates possible developments on the Hungarian side of the system, focusing on the historical floodplain areas (marked with a red box in Fig. 2). The canals of the Szigetköz Historical Floodplain Water Replenishment System (later referred to as HFWRS) meander through this human-inhabited and agriculturally cultivated part of Szigetköz. The system extends from the flood protection levees of the Old Danube across Szigetköz Island to the Mosoni-Danube. In many places, these canals connect the beds of old branches of the Danube, providing a dense network of channels that make this area rich in water and maintain the landscape's mosaic-like nature.

The flow within these channels is controlled by approximately 100 regulating hydraulic structures. The channel system has multiple functions: (1) drainage of excess water during wet periods, (2) water replenishment in dry conditions, (3) supplying water for irrigation and fisheries, (4) acting as blue and green corridors, providing spawning areas, and (5) offering transportation and recreational opportunities.

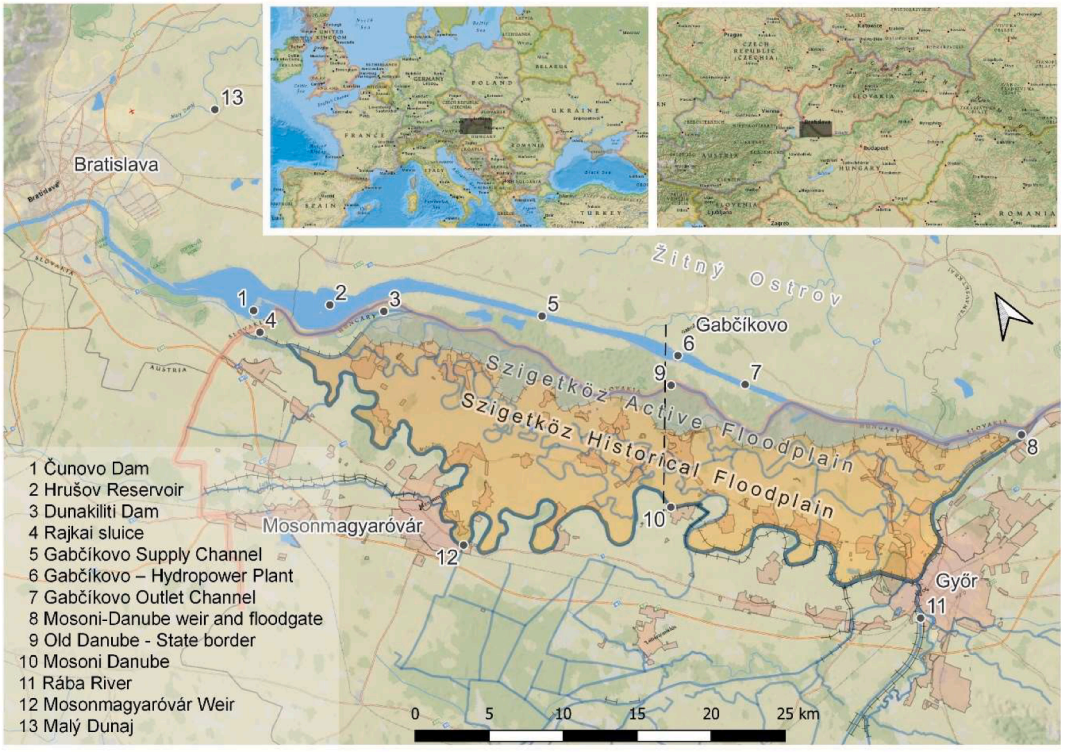

Fig. 1. An Overview Map of the Szigetköz Area
ESRI provided the base map with additions using QGIS software. The dashed line represents the location of the cross-section shown in Fig. 2.

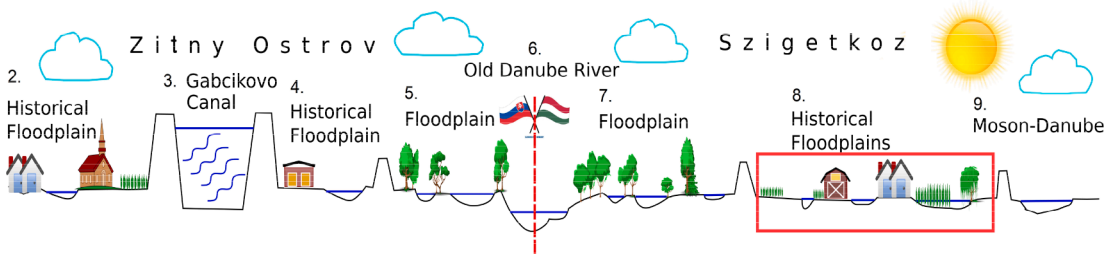

Fig. 2. Spatially Separated Water Bodies in The Szigetköz-Csallóköz (Žitný Ostrov) Area.
1. Maly Dunaj (on the Slovakian side, not shown in the Figure), 2. Žitný Ostrov Historical Floodplain channels, 3. Gabčíkovo supply canal, 4. Slovakian side historical floodplain water system, 5. Slovakian side active floodplain water replenishment system, 6. Old Danube, 7. Hungarian side active floodplain water replenishment system; 8. Hungarian side historical floodplain water replenishment system, 9. Mosoni-Danube.

Multiple function assessment also necessitates the involvement of various stakeholders with diverse and sometimes conflicting objectives. Agriculture experts anticipate a surge in irrigation demands. Settlements express an interest in investing in eco-tourism, capitalising on the proximity of surface waters. Fisheries and forestry also have their respective agendas. Effective water management strives to balance these competing demands and their need for available resources. The following sections detail our activities to gather and analyse water-related regional development project ideas and prioritise them with a novel approach.

3. Method

The methods and results presented in this paper assess proposed developments in and around the Szigetköz Historical Floodplain Water Replenishment System. Project priorities rely on a process that accounts for the three pillars of sustainable development (environmental, social, and economic sustainability). Stakeholder involvement activities drive the ranking of project ideas. The Insula Magna Project (Anon., Széchenyi István University 2024) created an opportunity to investigate current environmental and societal problems and formulate water-related project ideas that help develop a sustainable Szigetköz region. The authors of this article adopted a bottom-up approach, as shown in Fig. 3. The assessment included a novel idea to involve attitude scores (AS) and integrative potential (IP) as two components of a multi-criteria analysis (MCA). The analysis considers the objectives of stakeholder groups when calculating AS for each project idea. At the same time, counting the number of distinct water management issues a project idea encompasses produces the IP. The MCA combines these indicators to evaluate each project idea's potential to be successful in sustainably developing the Szigetköz floodplain. The methodology ensures that the three pillars of sustainable development objectives are met by considering stakeholder information, site-specific characteristics, and the principles of integrated water management.

There were three main research components: (1) stakeholder involvement activities, (2) information processing, and (3) prioritising project ideas. The following sections will discuss the applied methods (indicated with letters (a) – (i) in Fig. 3) for each research component.

3.1. Stakeholder involvement activities

The researchers focused on water management problems and objectives during the stakeholder involvement by inviting them to formulate project ideas. This activity consisted of three different steps, namely:

1. Interviewing the mayors of Szigetköz settlements.
2. Distributing questionnaires to different water users and other concerned parties (such as farmers, fisheries, food production companies, water-tourism firms, entrepreneurs, and NGOs)

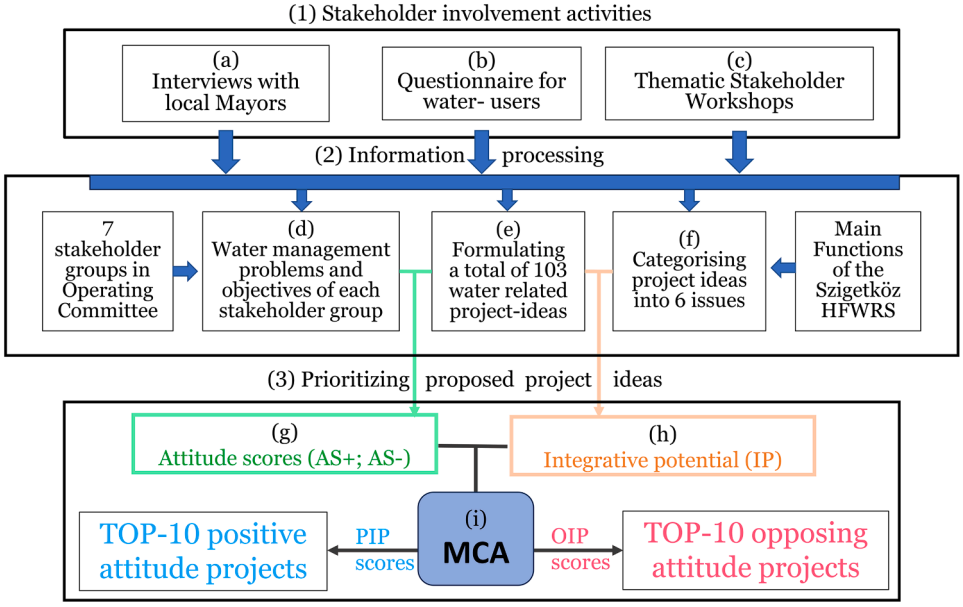

Fig. 3. Flowchart of the research activity presented in this paper. Research starts with stakeholder involvement activities and continues through information processing to prioritise proposed project ideas, using multi-criteria analysis (MCA).

3. Organising thematic workshops (for all stakeholder groups) to discuss project ideas and issues

Our research framework used snowball sampling (Leventon et al., 2016) to perform stakeholder identification. The process began with representatives of distinct stakeholder groups (see Table 1) already involved in the Szigetköz Operating Committee.

Members of the wider Szigetköz community were systematically contacted. Throughout the stakeholder involvement activities between June 2021 and March 2022, over 200 individuals were engaged, with at least 100 people actively participating in one or more of the conducted activities. Data collection during the activities followed the mixed methods approach, with qualitative and quantitative data gathered (Lukman et al., 2023).

3.1.1. *Interviews with local mayors (Fig. 3, box (a))*

Local mayors in the Szigetköz area were interviewed in 2021 and at the beginning of 2022, primarily focusing on *settlement development* (Kézai et al., 2022). There was high settlement participation—23 out of 24 mayors cooperated—and gave detailed answers to 11 thematic questions about water management issues. The questions dealt with water management issues in both urban and rural areas. They also covered topics from water damage prevention to drinking water and irrigation water demands to the possibilities of wetland rehabilitation in municipal areas. Mayors identified and articulated the most significant number of proposed projects of all the groups who participated in this research.

3.1.2. *Questionnaire for water users (Fig. 3, box (b))*

This stakeholder involvement action focused on all stakeholder groups except *settlement development* which was covered by interviews among mayors.

Google Forms platform hosted the questionnaire online for three weeks, from Oct. 14 to Nov. 03, 2021. The survey team contacted nearly 100 potential stakeholders personally, by email, telephone, and in person. Finally, 21 stakeholders participated and filled out the questionnaire. The participants represented all the sectors related to water management, as shown in Fig. 4.

The questionnaire consisted of 6 to 11 short-answer or multiple-choice questions, depending on the type of stakeholder filling out the form. Stakeholders actively using or planning to use surface or subsurface water resources had five additional questions regarding water usage. The questions concerned stakeholders' satisfaction or dissatisfaction with the operation of the water replenishment system as well.

Table 1
Seven Stakeholder Groups. These groups were considered while analysing stakeholder involvement activities. The corresponding abbreviations and icons are used in figures throughout the article.

Environmental- and nature protection	(NP)	
Agriculture and food production	(AC)	
Forestry and hunting	(FO)	
Fisheries and angling	(FI)	
Water-related tourism and recreation	(TO)	
Settlement development	(SE)	
Water management and damage prevention	(WM)	

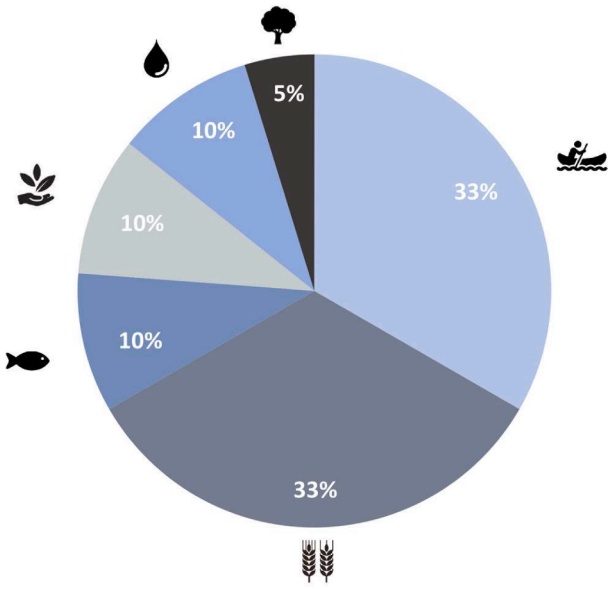

Fig. 4. Distribution of Questionnaire Participants Among Stakeholder Groups.

The questionnaire addressed water use, available water quantity, and water quality issues. It also surveyed individual perceptions of problems and development preferences.

3.1.3. *Thematic workshops (Fig. 3, box (c))*

The authors organised four thematic workshops and invited representatives from all the stakeholder groups. They hoped to have an active dialogue and obtain detailed information and insight into each group's perspective. In February and March 2022, the workshops dealt separately with (1) strategic issues of the Szigetköz Operation Committee, (2) specific development possibilities of the HFWRS, (3) irrigation possibilities of agricultural producers, and (4) the development of blue-green infrastructure in settlements. An average of 20–25 participants took part in each event. The photographs in Fig. 5 show an example of the participatory activities in one of the workshops.

During the workshops, stakeholders shared their views on water management problems and possible developments after attending the presentations of water managers and researchers. Representatives of different stakeholder groups used coloured post-it notes (yellow: agriculture, orange: settlement development, pink: fisheries, blue: water-related tourism, green: nature protection, purple: forestry, white: water management) to give their insights.

3.2. *Information processing*

The three stakeholder involvement activities generated a plethora of feedback (much of it uncategorised), ranging from generally formulated water management-related problems through site-specific demands to concrete project ideas. Information processing involved problem and objective evaluation followed by project clarification and organization. The seven stakeholder groups (see Table 1) formed the basis for organising feedback and later identifying the interests of different water user sectors. This arrangement reflected the stakeholder groups represented in the Szigetköz Operating Committee.

3.2.1. *Water management problems and objectives (Fig. 3, box (d))*

Stakeholder involvement activities were essential to determine each group's main water management issues and objectives. These issues and objectives were derived partly from questionnaire answers and partly from interviews on problems and development possibilities. Demands and concerns expressed by group representatives on workshops joined the list. These issues and objectives helped to assess stakeholder group

Fig. 5. Pictures from the Second Workshop in Kimle on Feb. 17, 2022.

interests related to each proposed project idea in the later stages of analysing project ideas by allocating attitude scores (see section 3.3.1).

3.2.2. Formulating project ideas (Fig. 3, box (e))

A total of 103 proposed project ideas were formulated during the stakeholder involvement activities. Mayors of the settlements and local water management agencies proposed most project ideas. However, individual water users who participated in questionnaires or workshops also contributed. These project ideas are all site-specific and involve a wide variety of possible developments. The typical examples of the collected project ideas are:

- Building new water replenishment canals
- Forming irrigation communities
- Increasing the capacity of existing canals
- Aquatic habitat restoration
- Constructing new structures to control water levels
- Stormwater management in settlements
- Connecting new areas to urban sewer systems
- Modernising wastewater treatment plants
- Creating and developing beaches along water bodies

The overwhelming majority of project ideas concern the historical floodplain of Szigetköz, with a smaller number addressing issues on the active floodplain area.

3.2.3. Categorising project ideas (Fig. 3, box (f))

A necessary part of information processing was quantifying the various water management issues associated with each project idea. This categorisation will later serve as the basis for deriving each project idea's integrative potential (see section (h) 3.3.2). The categorisation process considered a total of six water-related issues (see Table 2). Five of these six issues matched the five main functions of the HFWRS (as described in section 2). In contrast, another issue covered the currently separate system of urban water utilities and their developments.

3.3. Prioritising project ideas

The objective of prioritising project ideas was to identify those adopting a holistic approach, addressing multiple water-related issues simultaneously, and garnering support from most stakeholder groups. We also ranked project ideas that potentially generated stakeholder conflicts to gain a comprehensive understanding of their viability.

Table 2
The Six Water-Related Issues Used to Categorise Proposed Project Ideas.

1.	Water damage prevention
2.	Development and maintenance of water replenishment canals
3.	Excess water usage from surface or subsurface sources
4.	Restoration of habitats
5.	Water-related recreation, tourism, and transportation
6.	Urban water utility services developments

Typically, a multi-factorial method, such as multi-criteria analysis, is employed for such evaluations (Worley et al., 2023). The first evaluation attempt used identical weights for the multiple factors to rank projects (Mubialiwo et al., 2021). However, a sensitivity analysis examined if varying weights may change the relative order of the projects (Shafiei et al., 2022).

This research entailed processing information from stakeholder involvement activities to assess each proposed project. This task involved assigning attitude scores (Fig. 3, box (g)), evaluating the project's integrative potential (Fig. 3, box (h)), and determining the top 10 positive attitude and top 10 opposing attitude integrative projects using multi-criteria analysis (i).

3.3.1. Allocating attitude scores for each project idea (Fig. 3, box (g))

The evaluation was carried out for each proposed project idea (see section (e) 3.2.2) by using a single, three-step attitude scale of supporting (+1), being neutral (0), or opposing (−1) a project idea from the point of view of each stakeholder group (see Table 1). A project idea received a score of +1 from a stakeholder group if the project's goals aligned with that group's main objectives (Fig. 3, box (d), and 3.2.1). Likewise, if project goals hinder the objectives or demands of a group, a score of −1 is allocated. When a stakeholder group was unaffected by a project idea, a neutral score of 0 was assigned. Based on these scores, each project idea received a separate score for positive (eq. (1)) and negative (eq. (2)) attitudes toward it.

$$AS_i^+ = \frac{\sum I_i^+}{N_S} \quad (1)$$

$$AS_i^- = \frac{\sum I_i^-}{N_S} \quad (2)$$

AS_i^+ – positive attitude score of i^{th} project idea
AS_i^- – negative or opposing attitude score of i^{th} project idea
$\sum I^+$ – sum of positive attitude scores generated by i^{th} project idea,
$\sum I^-$ – sum of negative attitude scores generated by i^{th} project idea,
N_S – number of all stakeholder groups considered (7 in this study as of Table 1.).

The total number of stakeholders (N_S) normalized attitude scores to get a value between [0:1] in the case of AS_i^+ and a value between [−1:0] in the case of AS_i^-.

3.3.2. Evaluating project ideas based on their integrative potential (Fig. 3, box (h))

Each project idea (Fig. 3, box (e) and 3.2.2) was evaluated based on the number of issues it addressed (Fig. 3, box (f) and 3.2.3). Theoretically, a single project idea could connect to all six issues in Table 2. The evaluation team assumed that the more issues a single project idea concerned, the more integrative potential (IP) it had. The integrative potential of a project idea was calculated using Eq. (3).

$$IP_i = \frac{\sum C_i}{C_S}, \quad (3)$$

IP_i – integrative potential of i^{th} project idea

$\sum C_i$ – sum of the number of issues that the i^{th} project idea concerns,

C_S – total number of issues a single project idea can concern (6 in this study as of Table 2).

The total number of water-related issues (C_S) normalized integrative potential to obtain IP_i values between [0:1].

3.3.3. Determining top 10 positive and top 10 opposing attitude integrative projects (Fig. 3, box (i).)

The top 10 list of positive attitude integrative project ideas and the top 10 opposing attitude integrative project ideas were determined using multi-criteria analysis. These two top 10 lists were established based on the positive or negative attitudes score and the integrative potential of projects. The score reflects the weighted average of attitude scores and integrative potential calculated for each project idea. Eq. (4) determined the score for a project's *positive attitude integrative potential (PIP)*:

$$PIP_i = \frac{\left|w_1 \cdot AS_i^+\right| + w_2 \cdot IP_i}{w_1 + w_2} \cdot \delta \tag{4}$$

while Eq. (5) calculated the score for the project's *opposing attitude integrative potential (OIP)*:

$$OIP_i = \frac{\left|w_3 \cdot AS_i^-\right| + w_4 \cdot IP_i}{w_3 + w_4} \cdot \delta \tag{5}$$

where

$$\delta = \begin{cases} 1 \text{ if } AS_i > 0 \\ 0 \text{ if } AS_i = 0 \\ -1 \text{ if } AS_i < 0 \end{cases} \text{ the}$$

PIP_i – a score to rank i^{th} project idea among positive attitude integrative projects ($PIP_i = \varepsilon$ [0.00:1.00]),

w_1 – weight of AS^+ ε[0.00:1.00] (the significance of positive attitude score in positive attitude integrated project calculation)

w_2 – weight of IP, ε [0.00:1.00] (the significance of integrative potential in positive attitude integrated project calculation)

The sum of w_1 and w_2 equals to 1. ($w_1 + w_2 = 1.00$)

OIP_i – a score to rank i^{th} project idea among opposing attitude integrative projects (OIP_i ε [0.00:1.00])

w_3 – weight of AS^- ε [0.00:1.00] (the significance of negative attitude score in opposing attitude integrated project calculation)

w_4 – weight of IP ε [0.00:1.00] (the significance of integrative potential in opposing attitude integrated project calculation)

The sum of w_3 and w_4 equals to 1. ($w_3 + w_4 = 1.00$)

In PIP and OIP, the magnitudes of IP_i and AS_i are taken into account; therefore, the absolute value of AS_i is considered. To correct the result, the researchers accounted for the direction of the attitude score (positive, opposing or neutral); the unit step function (δ) is therefore applied to both equations.

Each project idea received a positive attitude integrative potential score (PIP_i) and an opposing attitude integrative potential score (OIP_i) based on Eqs. (4) and (5). A value of PIP_i nearer to 1.00 translates to a project with high integrative potential and numerous positive attitudes from stakeholder groups. On the other hand, values of OIP_i nearer to −1.00 indicate that a proposed project idea with high integrative potential generates considerable conflicting interests. Sorting the project ideas based on these scores produced the two top 10 lists.

4. Results

Engagement with stakeholders concerning water-related development ideas in the Szigetköz area spanned nine months, from 2021 to 2022. The subsequent results were determined using methods outlined in section 3.

4.1. Water management problems and objectives

Project idea analysis began with a qualitative assessment and synthesis of the feedback from participants of stakeholder involvement activities. The researchers investigated the various problems and suggestions of all stakeholder groups, and they determined the main objectives of each group based on the gathered information. As a result, key water management issues and objectives—or demands for action—were determined for each stakeholder group, as shown in Table 3.

Table 3 was the foundation for further analysing and evaluating proposed project ideas, particularly in allocating attitude scores.

4.2. Allocating attitude scores to project ideas

The stakeholder involvement activities generated 103 project ideas. Based on the established objectives of the seven stakeholder groups (see Table 3), the researchers assigned attitude scores for each project idea from the point of view of every group. The detailed result matrix consists of 103 rows—one for each proposed project idea and seven columns—one for each stakeholder group. The matrix, therefore, has 721 fields with values of −1, 0, or +1 (see Figs. 8 and 9 to see examples of allocated attitude scores).

As an example, project ID-71 (complex eco-touristic development in Győrladamér, including waterside nature trail, playground, pedestrian and bicycle bridge, and development of waterways on the water replenishment canals) is a project proposed by the mayor of Győrladamér and ranked first on the top 10 opposing attitude integrative project ideas list (Fig. 9). The project idea is aligned with the objectives of settlement development (SE) and serves the interest of the tourism and recreation (TO) stakeholder group; therefore, attitude scores of +1 were allocated from their point of view. However, the proposed project faces considerable opposition from nature protection (NP) since an increased disturbance of wildlife can be expected as an outcome of the project. Forestry (FO) and angling (FI) also have opposing attitude scores (−1) as a result of the expected transformation of the present waterfront characterised by gallery forests and currently a pleasant site for angling. Similarly, water management (WM) was considered to oppose the project, as maintenance works are expected to increase without direct income for the canal system operator. Finally, agriculture (AC) was considered unaffected; therefore, a neutral attitude score of 0 was assigned.

The cumulative sum of +1 scores amounts to 253, indicating that, on average, each project receives support from approximately 2–3 stakeholder groups. Meanwhile, 83 fields of −1 imply less than one opposing stakeholder group on average for each proposed project.

4.3. Integrative potential of project ideas

The collected project ideas were evaluated based on the number of issues (see Table 2) they addressed. Examples of the calculated integrative potential of projects can be seen in Figs. 8 and 9. The number of issues that each project concerns can be seen in Fig. 6. Each pie chart located on the map represents one project idea, and the coloured sections symbolise the different issues addressed by the project idea. The more colours a pie chart contains, the more issues a project idea integrates.

Many locations featured a combination of project ideas where water-related recreation and tourism, canal development and maintenance, habitat restoration, and excess water usage coincided. However, some purple dots represent urban water developments that did not consider any other issue, thus lacking the possible synergies that blue and green infrastructure solutions could offer.

Fig. 7 presents a statistical analysis of integrative potential. Fig. 7/a shows the number of project ideas related to different water management issues, while Fig. 7/b shows the distribution of the number of

Table 3
Water Management Problems and Objectives of the Seven Stakeholder Groups Considered During the Research.
These issues and objectives originated from stakeholder involvement actions – interviews, questionnaires, and workshops.

STAKEHOLDER GROUP	WATER MANAGEMENT PROBLEMS	OBJECTIVES
Environmental and nature-protection (NP)	• Water demand of the ecosystem is undetermined → Knowing this is a limiting condition for all further water uses. • Nature conservation aspects neglected during maintenance works! • Protection of water quality. • Reduction of pollution from agriculture, animal farms and food processing.	• Determine the desired water exchange duration for channels. (varies according to habitat types). • Establish new bypass channels to preserve standing water habitats. • Create a wider maintenance lane along canals. • Establish shading forest strips. • Increase monitoring of water quality issues.
Agriculture and food production (AC)	• Potential of newly formed irrigation communities to increase the use of surface and subsurface water resources. • Challenges of mitigating damage caused by beaver and nutria.	• Monitor changes in surface and subsurface water resources. • Raise groundwater levels in Upper Szigetköz. • Beaver and nutria management plan.
Forestry and hunting (FO)	• Limited forest areas on the historical floodplain. • Forestry activities' interference with other uses, especially water tourism and sometimes water management. • Challenges of mitigating damage caused by beaver and nutria.	• Forest (or reforest) canal banks • Coordinate activities with water management. • Communicate with tourists (both on land and water). • Develop and implement a beaver and nutria management plan.
Fisheries, anglers (FI)	• Inhibition of fish reproduction by human disturbance and canal operation • Increasing conflicts with water tourism.	• Rehabilitate natural spawning places. • Increase the reliability of water levels and discharges into the replenishment channel system.
Water-related tourism and recreation (TO)	• An increase in kayak-canoe tourism in the historical floodplain channels, with resultant infrastructure and riverbed maintenance demands.	• Regularly coordinate with nature conservation, forestry, and anglers. • Construct canoe slides next to hydraulic structures.
Settlement development (SE)	• Need to address rainwater drainage problems and rehabilitation of low-lying areas—wetlands. • Access to water and built infrastructure is insufficient. • Potential for water-related tourism development.	• Offer tenders and applications for stormwater management projects, including blue and green infrastructure and eco-touristic projects.
Water management (WM)	• Requirements for regular maintenance work on canals (mowing, dredging) and hydraulic structures to accommodate the needs of water users • Areas without sewer network, wastewater treatment plant's capacity problems	• Provision of material, human, and financial resources necessary for maintenance. • Protection of maintenance lanes. • Application of a water allocation model. • Provision of drinking water supply and wastewater collection and treatment.

issues concerned by single project ideas.

Seventy-one project ideas (~ 70 %) relate to developing and maintaining water replenishment canals. Forty-eight project ideas deal with water-related recreation, tourism, and transportation, while 46 are partly concerned with restoring habitats. A total of 43 proposals would generate excess water usage. The least frequent types of proposed project ideas concerned water damage prevention with 17 projects—and urban water utility development with 11 projects. Another aspect of the statistics of this categorisation (presented in Fig. 7/b) shows that a mere 29 % of project ideas concern only one water management issue. Most of these are urban water utility development and stormwater drainage projects. Around 67 % of project ideas concern two or three issues, and another 7 % connect to four or five issues. However, no project idea was concerned with all six issues.

4.4. *Prioritising project ideas*

The top 10 lists for positive attitude integrative project ideas (PIP) and opposing attitude integrative project ideas (OIP) are the main outcomes of this research. The PIP and OIP scores used to rank project ideas were determined by applying Eqs. (4) and (5), detailed in section 3. The weights of the equations were uniformly set to 0.5 as a first estimate, meaning $w_1=w_2=w_3=w_4=0.5$.

The top 10 positive attitude integrative project ideas were ranked based on the PIP score. A high PIP score indicates that a project idea addresses many issues and has a high degree of integration, this is called an integrated project. This high score also establishes that there is broad consensus regarding the project goals between stakeholder groups. These projects appear in Fig. 8.

On the other hand, the list of the top 10 opposing attitude integrative project ideas (Fig. 9) shows proposals that concern many issues but generate wide-scale conflicts of interest between stakeholder groups.

The distribution of the calculated OIP and PIP scores are shown in Fig. 10. The scores represent two scores for each project.

PIP scores (Fig. 10) follow a normal distribution, while OIP scores have some irregularity. This pattern is because over half of the projects (54) attained an OIP score between −0.10 and 0.00. Effectively, the OIP score of these projects was 0, and their negative attitude scores (AS^-) were equal to 0. These numbers mean that no interests opposed these projects.

Many of these projects scored a high PIP value if their integrative potential was at least medium. Such projects mainly concerned wetland restoration and further water replenishment of canals while providing possibilities for use of excess water, water-related tourism and recreation, or both.

Some of these projects, however, received PIP values closer to 0, indicating that their IP was low. Such projects were urban rainwater and wastewater projects (which have widespread support but failed to include an integrative approach).

Further evaluation of weighing factors (w1, w2, w3, w4) revealed their influence on the PIP and OIP scores. The analysis evaluated weighing factors' impact on the top 10 positive and opposing attitude lists as well. The combinations examined are shown in Table 4

We assessed the number of project ideas remaining in the top 10 lists in all cases, compared to the original calculations that used equal weights ($w_1=w_2=0.50$ for PIP; $w_3=w_4=0.50$ for OIP). The results of the sensitivity analysis are presented in Fig. 11.

The sensitivity analysis indicated that the top 10 ranking of project ideas based on PIP and OIP scores is mildly sensitive to changing weights. Even with dramatic adjustments (1:4 and 4:1 ratio), 70–90% of the original project ideas remained on the top 10 lists for positive or opposing attitude integrative project ideas, as seen in Fig. 11.

5. Discussion

The results of this paper have specific implications about the

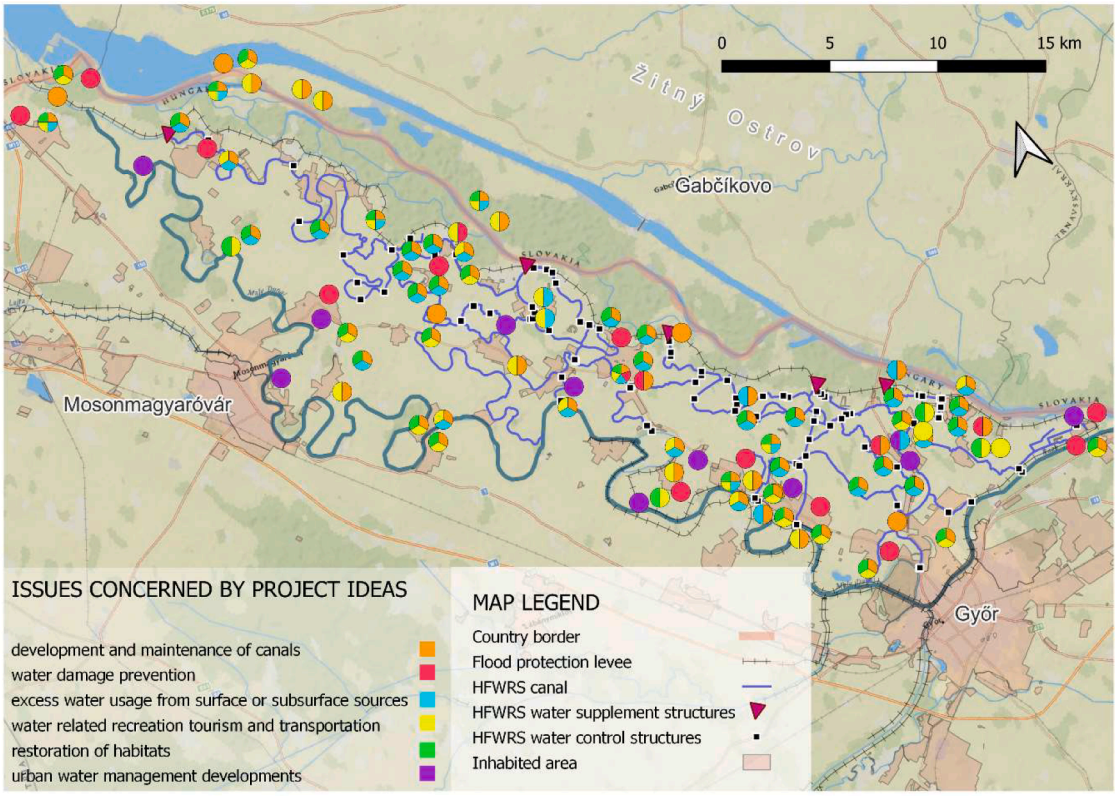

Fig. 6. 103 Project Ideas Collected by the Researchers During Stakeholder Involvement Activities.
Each pie chart represents one project idea. The pie charts overlay the location of the proposed project. The coloured segments of the pie charts correspond to the different issues that each project idea addresses. (base map by EsriTM, data from North-Transdanubian Water Directorate (ÉDUVÍZIG), edited with QGIS).

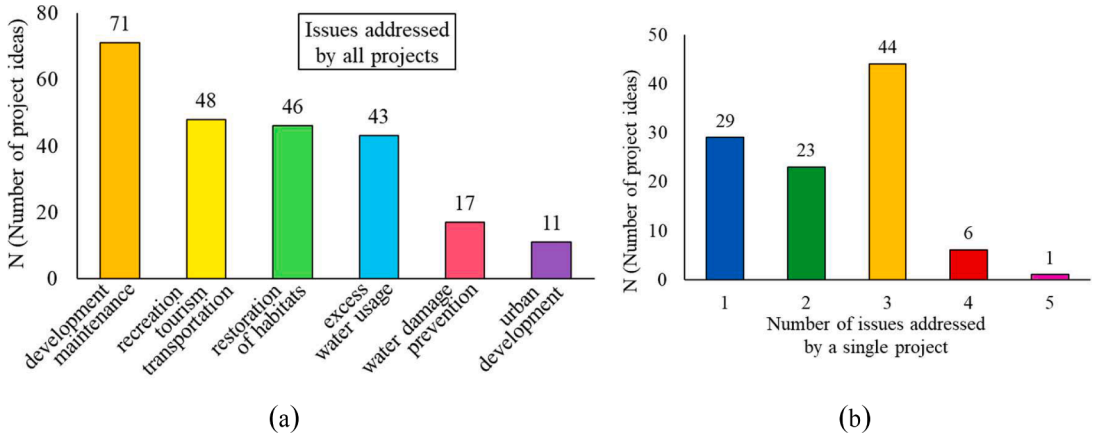

Fig. 7. Statistics of the Integrative Potential of the 103 Proposed Project Ideas.
a) Number of project ideas (N) relating to the six water management issues presented in Table 2.
b) Number of project ideas (N) relating to a certain number of concerned issues.

Szigetköz area, which provided the information for the case study and general implications regarding the innovative methodology used to prioritise project ideas.

5.1. *Specific implications about Szigetköz*

The main goal of this study was to rank and prioritise project ideas, resulting in the top 10 lists of positive attitude integrative projects (Fig. 8) and opposing attitude integrative project ideas (Fig. 9). The most important finding of these lists is that positive attitude integrative project ideas are mainly those that create, restore, or revitalise waterbodies and wetlands through water retention. This finding aligns with Demetropoulou et al. (Demetropoulou et al., 2019), whose study displayed a top 10 list of measures, eight of which fell into the "promoting efficient and sustainable water use" category.

In the results of this paper (Fig. 8), eight projects on the list of top 10 positive attitude integrative project ideas involve habitat restoration through extending or further developing the historical floodplain canal system. The expansion of water surfaces through these projects amplifies ecosystem services and potentially attracts tourists.

While these projects benefit local actors, a common trait among them is that the value of added individual utilities and private benefits cannot

TOP-10 POSITIVE ATTITUDE, INTEGRATIVE PROJECTS

RANK	ID	LOCATION	PROJECT	ATTITUDE SCORES: Environ., nature protection (NP)	Agricult., food-prod. (AC)	Forestry, hunting (FO)	Fisheries, angling (FI)	Tourism, recr. (TO)	Settle-ment develop. (SE)	Water manag. (WM)	ΣI_i^+	ΣI_i^-	AS^+	CONCERNED ISSUES: develop-ment and mainte-nance of canals	water damage preven-tion	excess water usage - surface / subsurf.	water related recr. tourism transp.	restora-tion of habitats	urban water manag. develop-ments	ΣC_i	IP	TOP 10 SCORES: PIP_i	OIP_i
1.	61	Dunaszeg	Increase the water replenishment of the Dunaszeg oxbow lake.	1	0	1	1	1	1	0	**5**	**0**	0.71	1	0	1	1	1	0	**4**	0.67	**0.69**	0.00
2.	48	Ásványráró	Create a computer model to support the operation of HFWRS.	1	1	1	1	1	1	1	**7**	**0**	1.00	1	1	0	0	0	0	**2**	0.33	**0.67**	0.00
3.	52	Ásványráró	Replenish and convert for multi-use the lake inside the village centre.	0	0	0	1	1	1	0	**3**	**0**	0.43	1	1	1	1	1	0	**5**	0.83	**0.63**	0.00
4.	1	Rajka	Replenish the Rajka Drainage Canal, a cross-border project with the Slovakian side.	1	1	1	0	0	1	0	**4**	**0**	0.57	1	0	1	1	1	0	**4**	0.67	**0.62**	0.00
5.	26	Máriakálnok	Revitalise and replenish the water supply of a backwater around the Chapel.	1	0	1	1	1	1	0	**5**	**0**	0.71	1	0	1	0	1	0	**3**	0.50	**0.61**	0.00
6.	22	Halászi	Widen the maintenance lane along Nováki-channel and replant the forest strip with the help of local residents and students.	1	-1	1	0	1	1	1	**5**	**-1**	0.71	1	0	0	1	1	0	**3**	0.50	**0.61**	-0.32
7.	78	Győrzámoly	Revitalise Kopaszdűlői-canal.	1	1	1	1	0	0	0	**4**	**0**	0.57	1	0	1	0	1	0	**3**	0.50	**0.54**	0.00
8.	73	Győrladamér	Revitalise a backwater called Patházi-branch.	1	0	1	1	0	1	0	**4**	**0**	0.57	1	0	1	0	1	0	**3**	0.50	**0.54**	0.00
9.	91	Vámosszabadi	Increase water replenishment of the Körtvélylaposi canal and dig new canals to connect nearby wetlands.	1	1	0	1	0	0	1	**4**	**0**	0.57	1	0	1	0	1	0	**3**	0.50	**0.54**	0.00
10.	27	Máriakálnok	Rehabilitation of the Kálnoki-Danube branch and negotiating the operational rules.	-1	1	-1	-1	1	1	1	**4**	**-3**	0.57	1	0	0	1	1	0	**3**	0.50	**0.54**	-0.46

Fig. 8. Top-10 Positive Attitude Integrative Project Ideas Based on the PIP Value.

TOP-10 OPPOSING ATTITUDE, INTEGRATIVE PROJECTS

RANK	ID	LOCATION	PROJECT	ATTITUDE SCORES: Environ., nature protection (NP)	Agricult., food-prod. (AC)	Forestry, hunting (FO)	Fisheries, angling (FI)	Tourism, recr. (TO)	Settle-ment develop. (SE)	Water manag. (WM)	ΣI_i^+	ΣI_i^-	AS^-	CONCERNED ISSUES: develop-ment and mainte-nance of canals	water damage preven-tion	excess water usage - surface / subsurf.	water related recr. tourism transp.	restora-tion of habitats	urban water manag. develop-ments	ΣC_i	IP	TOP 10 SCORES: PIP_i	OIP_i
1.	71	Győrladamér	Complex eco-tourist development in Győrladamer (waterside nature trail, playground, pedestrian and bicycle bridge, development of waterways on the HFWRS).	-1	0	-1	-1	1	1	-1	**2**	**-4**	-0.57	1	0	0	1	1	0	**3**	0.50	0.39	**-0.54**
2.	30	Kisbodak	Riverbed developments to make the Old Danube navigable for ships.	-1	0	-1	0	1	1	0	**2**	**-2**	-0.29	1	0	1	1	1	0	**4**	0.67	0.48	**-0.48**
3.	27	Máriakálnok	Rehabilitation of the Kálnoki-Danube branch and negotiating the operational rules.	-1	1	-1	-1	1	1	1	**4**	**-3**	-0.43	1	0	0	1	1	0	**3**	0.50	0.54	**-0.46**
4.	53	Ásványráró	Create three groundwater-fed lakes and a Residential Park in a greenfield project.	-1	-1	0	1	0	1	-1	**2**	**-3**	-0.43	1	0	1	0	1	0	**3**	0.50	0.39	**-0.46**
5.	17	Dunasziget	Dredge and replenish the water supply of Újhídi-ág – a successive Danube branch – to create better possibilities for water tourism.	-1	0	0	0	1	1	0	**2**	**-1**	-0.14	1	0	1	1	1	0	**4**	0.67	0.48	**-0.40**
6.	40, 47, 59, 65, 70	Kimle, Hédervár, Dunaszentpál, Dunaszeg, Győrladamér	Dredge the Mosoni-Danube and increase water replenishment to increase water depth.	-1	0	0	-1	1	1	1	**3**	**-2**	-0.29	1	0	1	1	0	0	**3**	0.50	0.46	**-0.39**
7.	63, 79, 103	Dunaszeg, Győrújfalu, Vének	Small-boat harbour, boat launch and regular cruising on the Mosoni-Danube.	-1	0	-1	0	1	1	0	**2**	**-2**	-0.29	1	0	0	1	1	0	**3**	0.50	0.39	**-0.39**
8.	42	Darnózseli	Construct water level control structures on the Nováki canal (with canoe slide and fish passage).	-1	0	-1	-1	1	1	1	**3**	**-3**	-0.43	1	0	0	1	0	0	**2**	0.33	0.38	**-0.38**
9.	39, 9, 25, 57	Kimle, Dunakiliti, Máriakálnok, Dunaszentpál	Develop beach, water-stage, and waterfront community space.	-1	0	-1	-1	1	1	0	**2**	**-3**	-0.43	1	0	0	1	0	0	**2**	0.33	0.31	**-0.38**
10.	22	Halászi	Widen the maintenance lane along Nováki-channel and replant the forest strip with the help of local residents and students.	1	-1	1	0	1	1	1	**5**	**-1**	-0.14	1	0	0	1	1	0	**3**	0.50	0.61	**-0.32**

Fig. 9. Top-10 Opposing Attitude Integrative Project Ideas Based on the OIP Value.

be readily estimated beforehand, making it difficult for private contributors to invest in such developments. Hence, these projects often require public financing. Therefore, it is crucial to accurately calculate the financial costs and achievable benefits to demonstrate these proposed projects' financial and beneficial justification. The Dutch Meuse region rehabilitation is an excellent example of managers calculating and presenting a project's additional social and economic benefits before investing in it (Van Looy and Kurstjens, 2023), (Weich, 2011). It is crucial, however, to involve all possible ecosystem services (Hornung et al., 2019) when calculating benefits; otherwise, the evaluation will be inherently biased.

5.1.1. *Pursuing OIP top 10*

In contrast with positive attitude projects, the top 10 list of opposing attitude integrative projects (OIP, see Fig. 9) mainly involve proposals in which specific actors try to create or get better access to existing water bodies for direct, personal, and or financial benefits. These projects do not aim to restore the historical state of the floodplains but rather to develop waterbodies and shores to be more accessible for tourism and recreation. The projects naturally conflict with nature protection and other water users who aim to maintain their current position to access waters (e.g., anglers) or maintain land use on water shores (agriculture, forestry). *They are highly integrative but require negotiation between*

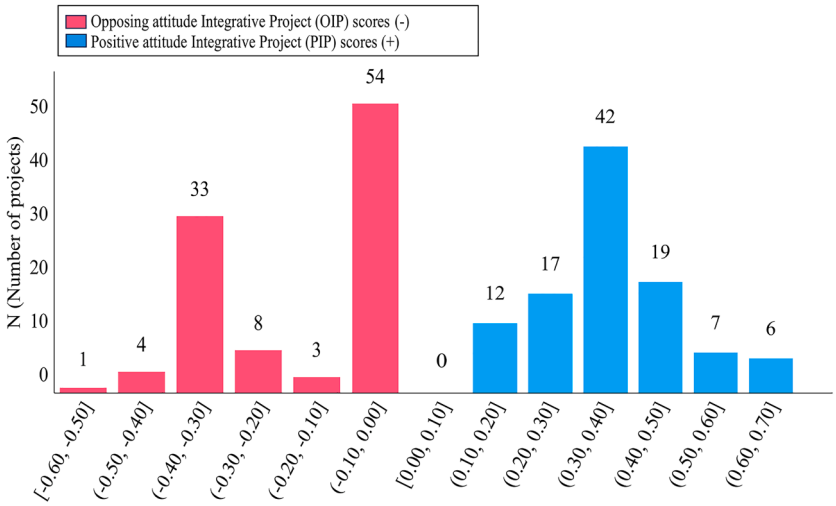

Fig. 10. Number of Projects (N) Receiving Certain Ranges of OIP and PIP scores.

Table 4
Weight factors used to study their effect on integrative potential and attitude score.

Analysis	w_1 (Eq. (4))	w_2 (Eq. (4))	w_3 (Eq.5)	w_4 (Eq.5)
Original 1:1	0.5	0.5	0.5	0.5
2:1	0.66	0.33	0.66	0.33
1:2	0.33	0.66	0.33	0.66
4:1	0.80	0.20	0.80	0.20
1:4	0.20	0.80	0.20	0.80

stakeholders to resolve negative impacts. They would be the next ten projects (after PIP top 10) worth the effort of negotiating to a resolution.

The lowest-ranked projects on both lists are those urban water management projects that fail to integrate multiple purposes. These projects are neither integrated nor do they involve or create common interests for multiple stakeholder groups; therefore, they cannot generate widescale positive attitude scores among different sectors. Integrated water management and implementation of nature-based solutions could facilitate projects to move up from lower rankings. Based on stakeholder involvement, it is possible to connect project ideas, thus making them more integrated.

In this research, stakeholder feedback was not prioritised based on their level of interest, influence, or other criteria, as suggested in previous studies (Sharpe et al., 2021). Incorporating such considerations in future studies can further enhance the decision-making and ranking process.

5.1.2. *Combining AS and IP*

Displaying the attitude scores and the integrative potential on a common figure (Fig. 12) provides more insights into the outcomes of project ranking. The 103 project ideas are represented in Fig. 12/a) and b) from different aspects. In Fig. 12/a), the horizontal axis shows negative attitude scores (AS^-), while the integrative potential (IP) is on the vertical axis. In Fig. 12/b), projects' positive attitude score ($AS+$) and integrative potential are plotted. The square area with unit long sides (the entire graph area with pale yellow background) represents all possible combinations of AS and IP. The size of the dots is proportionate to the number of projects with identical AS and IP scores.

The top 10 opposing attitude projects based on the ranking by the OIP score appear on the outer edge of plotted projects in Fig. 12a, labelled with red letters. The top 10 ranked positive attitude projects (based on PIP scores) are marked in Fig. 12a) to show their location in the opposing event space. The top 10 positive attitude projects according to PIP scoring are highlighted in Fig. 12b) in blue. The locations of the top 10 opposing attitude projects are also indicated in Fig. 12b).

The results point to an interesting, uneven distribution on the two planes. Many projects have zero or close to zero negative attitude score

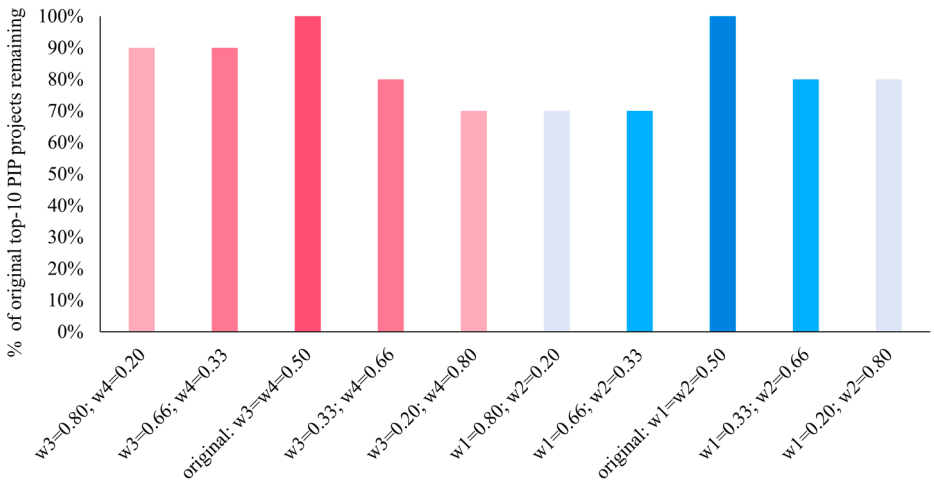

Fig. 11. Percentage of the Original Top 10 Project Ideas Remaining Top 10 After Changing Weighting for OIP and PIP projects.

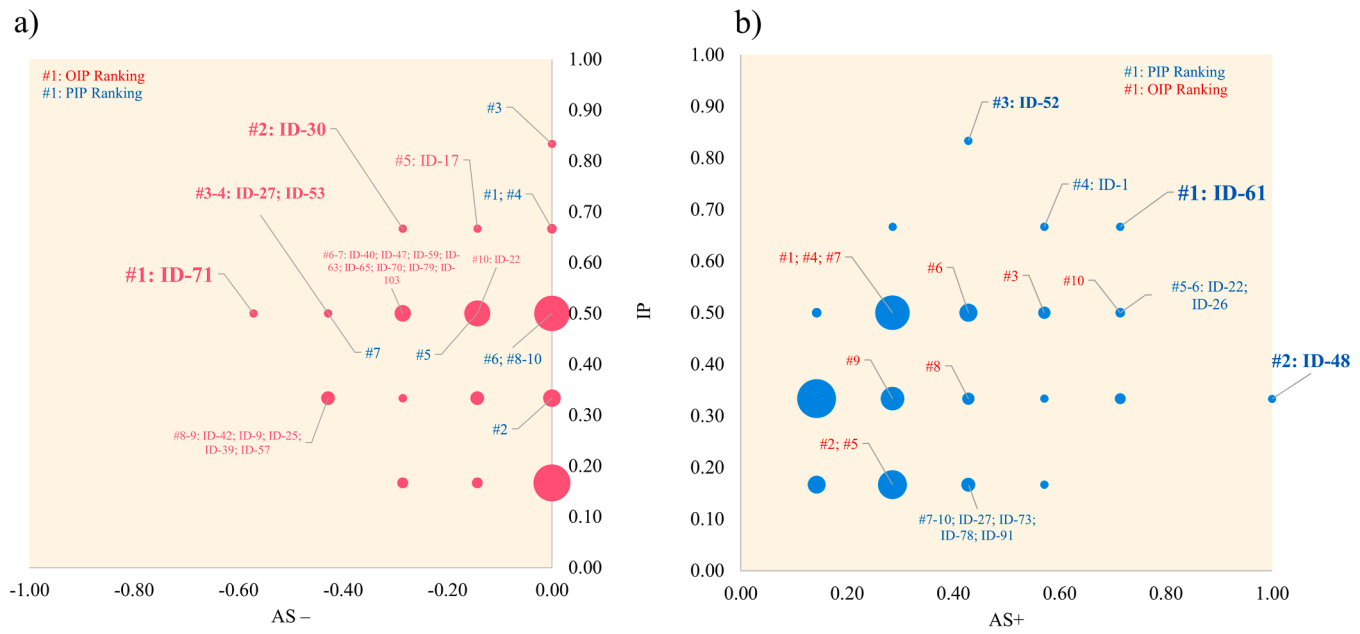

Fig. 12. Scatter Plot of the 103 Project Ideas a) based on their negative attitude score (AS-) and integrative potential (IP), and the same 103 project ideas represented on b) based on their positive attitude score (AS+) and integrative potential (IP). The top 10 positive- (blue) and opposing- (red) attitude projects (see Figs. 8 and 9) are displayed on both parts of the figure, indicated with their ranking, and the project ID.

values. These projects do not harm the interest of any stakeholder group. On the other hand, no project received zero positive attitude score values since it was considered that all projects were initiated by at least one out of the seven stakeholder groups. Only one project received an AS^- value lower than −0.50 (no.71 with −0.57). In contrast, over a dozen projects reached an AS^+ value higher than 0.50, and one had a perfect 1.0 positive attitude score. These show that stakeholders support the investigated water-related project proposals more than oppose them.

Regarding integrative potential, most projects scored 0.17 (concerning one issue) or 0.50 (three concerned issues), as indicated in Fig. 7/b. It can also be seen in Fig. 12 that projects with low IP values generate low levels of common or conflicting interests (characterised by low absolute values of AS^- and AS^+). Interestingly, only projects that concern exactly three issues (IP=0.50) have had more than three adverse stakeholder groups (AS^- score of −0.57) out of the possible seven groups. Unexpectedly, projects with IP > 0.50 (those that concern four or five issues), thus being more complex and potentially affecting more stakeholder groups, did not generate more conflict of interest. However, the small number of such project ideas limit the probative value of this finding.

Project ideas ranked in the top 10 lists are also indicated in Fig. 12, in which the project numbers are red for OIP ranking and blue for PIP ranking, which is detailed in Fig. 9 and Fig. 8, respectively. As most opposing attitude integrative projects have low attitude scores, future workshops, negotiations, knowledge transfer, or simply suitable economic incentives could shift them towards the positive quarter of the coordinate system.

Further data collection for project clarification would help illuminate the complexity of some integrated projects, e.g., projects no 22 and 27, which rank in both top 10 lists. Future stakeholder consultations and workshops will serve to discover incentives to resolve counter-interests in such complex projects.

5.2. *General implications of the methodology and weighing*

The scientific literature on pre-assessing water-related regional development projects is minimal. Among the few previous studies, Demetropoulou et al. and Maurya et al. (Demetropoulou et al., 2019), (Maurya et al., 2020) applied multi-criteria analysis to assess proposed project ideas; however, the use of attitude scores and integrative potential in the MCA as two key measures of developing sustainable water-related projects is novel. These two measures help to implicitly assess—through the objectives of stakeholders and by quantifying the integrativeness of proposals—the compliance with the three SDG pillars of environmental, societal, and economic sustainability.

Another new phenomenon entails ranking opposing attitude integrative project ideas based on the OIP scores. The resultant rankings help identify project ideas that potentially benefit the environment or the economy but need stakeholder reconciliation and or reimbursement to succeed.

The sensitivity analysis of project rankings (Fig. 11) also showed that the proposed methodology produced a relatively stable set of top 10 positive and opposing attitude project ideas, constituting approximately the top 10 % of all project ideas. The sensitivity analysis results concluded that the PIP and OIP scores are minimally sensitive to changing weights. Fig. 12 reveals the reason for this, where most projects have an absolute value of AS that closely aligns with their IP value. Changing the weight coefficients mostly affects the ranking of those project ideas that score relatively high in one aspect and relatively low in the other. An example of such a project is no 48, which initially ranked second on the top 10 positive attitude projects. The project rose to the first spot when a greater weight was assigned to AS+. On the other hand, skewing the weights in favour of IP resulted in the same project dropping from the top 10 list.

A further analysis of the sensitivity of the proposed method produced the distributions of calculated PIP and OIP scores shown in Fig. 13a), b) respectively. PIP scores' distribution does change where an increasing AS value (lighter shades) moves them generally to the left (toward zero). However, that is not entirely consistent. The major change in distributions occurs between the intervals (0.3:0.4] and (0.4:0.5] where peak number of projects migrates to higher scores using lower AS weight values.

For OIP scores, if the [−0.1:0.0] bin is ignored, increasing the AS weights (lighter shades) moves the distribution to the right (toward zero). This transformation occurs because even though PIP and OIP scores are normalized, the *distribution* of AS and IP shows some

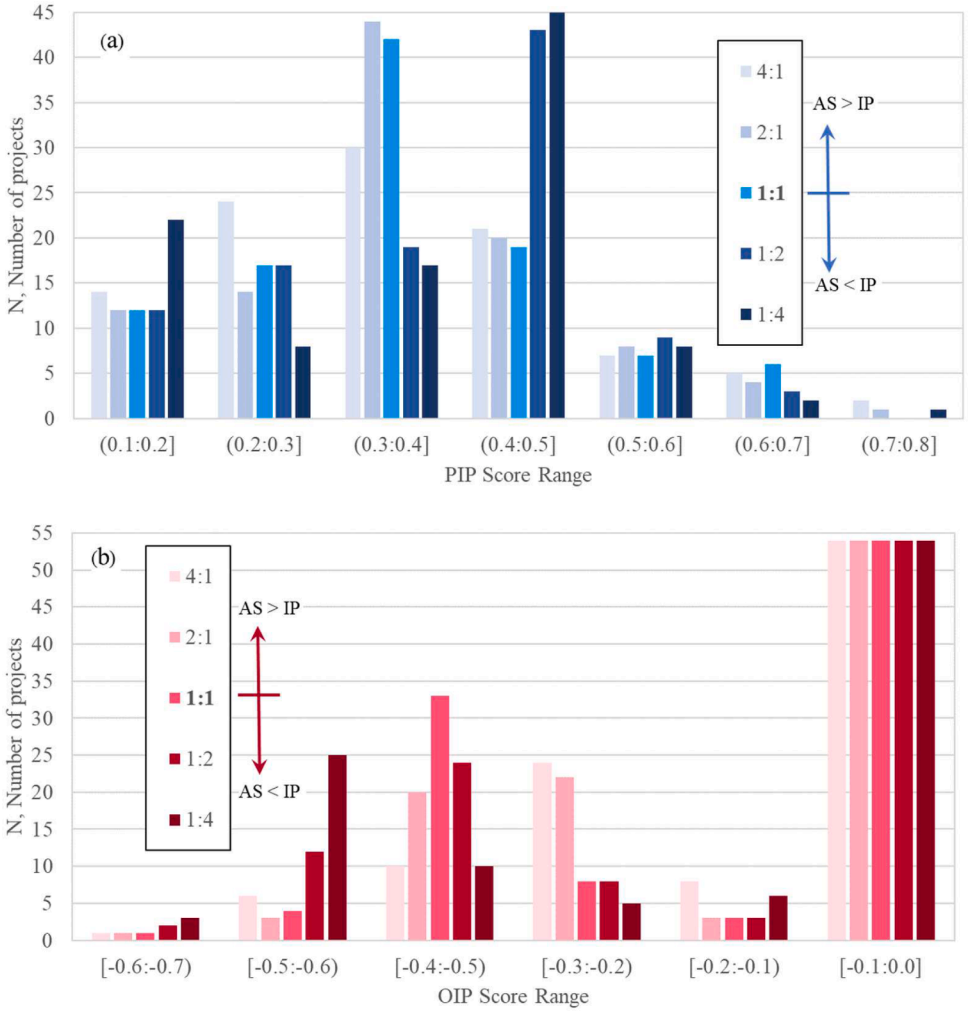

Fig. 13. Distribution of (a) PIP and (b) OIP Scores After Changing Weights. The ratio indicated for each plot describes the weights allocated for the attitude score and the integrative potential, respectively. (e.g., PIP 4:1 means w1=0.80, w2=0.20; while OIP 4:1 means w3=0.80, w4=0.20).

skewness. However, the change does not significantly affect the top 10 lists.

6. Conclusion

Development in floodplain areas must be integrated and balanced among the three sustainable development aims: environmental, social, and economic (Tsani et al., 2020). Environmental development on floodplains can yield extensive—direct and indirect—social and economic benefits. These projects can provide goods and services that benefit society, such as clean water, food, and carbon sequestration. Additionally, they can simultaneously enhance biodiversity and recreational spaces, improve water quality, increase flood resilience, and offer new economic opportunities through eco-tourism and sustainable agriculture. Therefore, identifying the level of interests that are common, conflicting, or both and adopting an integrated, holistic approach for sustainable projects in a floodplain setting is of particular importance.

Water replenishment efforts on the Danube floodplain around Szigetköz in the past 30 years have set the groundwork for the region's ongoing development. Today, local stakeholders increasingly seek access to and utilise water resources for various purposes. The research presented here assembled water-related development plans and regional project ideas, discovered stakeholder objectives, and evaluated proposed projects to rank and prioritise initiatives. The researchers employed a bottom-up approach and implemented numerous stakeholder engagement activities. As a result, over 100 proposed project ideas were collected. The pre-evaluation of this large array of water-related development projects required a novel approach to prioritise the projects.

This new methodology provides an effective tool to screen and identify specific types of project proposals that require further development in different ways. Top-ranked positive attitude integrative project (PIP) ideas often need cost-benefit calculations involving all ecosystem services to justify their economic sustainability. Top ranked opposing attitude integrative project (OIP) ideas on the other hand need conflict resolution and compensating mechanisms, to be socially sustainable. Finally, project proposals that were on the bottom of the lists need to be developed to be more integrated and make use of blue-green infrastructure and circular economical advancements, to foster environmental sustainability.

This prioritisation of project ideas enables decision-makers to minimise stakeholder conflicts and maximise economic benefits in the scope of sustainability for multi-functional developments within the limitation of available financial resources.

The results of project prioritisation must be re-assessed and validated with further stakeholder involvement activities. An important task in the future is to include local stakeholders in the process of agreeing upon specific weights used in the multi-criteria analysis, balancing the power of attitude scores and integrative potential in the outcome. Another

possibility is the sub-weighting of concerned issues during the calculation of integrative potential and the differentiating between stakeholder groups based on their level of interest and influence.

CRediT authorship contribution statement

Máté Chappon: Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **Attila Kálmán:** Writing – original draft, Methodology, Conceptualization. **Richard Ray:** Writing – review & editing, Visualization. **Katalin Bene:** Writing – review & editing, Supervision, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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