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Balancing the interaction between urban regeneration and flood risk management – A cost benefit approach in Ústí nad Labem

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ABSTRACT

Urban areas are hot spots of flood risk due to how urban development concentrates people and assets into hazard prone areas, reinforcing negative externalities on the welfare of urban residents. Mitigating flood risk in urban environments, however, is challenging. This is not only because the process generating flood risk is complex, but the objectives of city planners, residents and/or developers are also multi-faceted. Therefore, there are various trade-offs to be considered. One such problem across many areas of Europe and beyond is how to regenerate declined urban areas, to improve the welfare, prosperity, and image of the city. However, in turn, many areas within these cities will see this activity being traded-off against increased flood risk. Cost-benefit analysis represents a useful approach for assessing this trade-off, as a decision-support tool. In this paper we present an exploratory cost-benefit analysis of a potential urban regeneration project within the city of Ústí nad Labem (Czechia) that seeks to highlight the potential magnitude of such trade-offs that need to be more often actively considered as a core, rather than peripheral, element of urban regeneration. We present an exploratory framework that can be expanded upon and integrated into wider regeneration visions.

1. Introduction

Natural hazards pose a large threat to human society. For instance, in 2018 alone there was a total direct loss of €114bn, which was above the inflation-adjusted overall loss average of €100bn between 1988 and 2018 (Munich Re, 2019). Out of the range of natural hazard events, hydro-meteorological events (e.g., storms, flash floods, riverine floods) accounted for 82% recorded events and 72% of recorded monetary losses in 2018 (Munich Re, 2019). Within this set of natural hazards, flooding accounted for 40% of all-natural hazard losses since 1980, with a total global loss greater than €0.71tn.[1] Moreover, the threat from flooding is expected to increase due to a combination of climate change and the increasing exposure of socio-economic assets (IPCC, 2012, 2014, 2018, 2022). Therefore, it is important to note that floods cause such losses because of human behaviour (O'Keefe et al., 1976; Kelman, 2020; Chmutina and von Meding, 2019). The threat from flooding can be summarised as the product of three elements: hazard (the flood), exposure (what can be lost), and vulnerability (susceptibility to loss) (Kron, 2005), and for floods to negatively impact society each of the three elements must be present. While the hazard element is to some extent beyond human control, the exposure and vulnerability elements are not. They are the direct result of human decisions at various stages of planning and action. For instance, exposed assets and people have been increasingly present in floodplains (Jakubínský et al., 2021) due to the aesthetic and commercial benefits provided by them. Moreover, vulnerability is present as residents in floodplains are not fully protected against flooding because of behavioural heuristics within adaptation decision-making or that adaptation is not seen as cost-effective (Kuhlicke et al., 2020).

Human activities as the prime cause of flood impacts are most apparent in cities (Kaspersen et al., 2017). In an urban context, the exposure and vulnerability to floods develops a specific character. This is particularly the case of old- and post-industrial cities, which face a range of problems due to changing socio-economic conditions, such as population, economic, and institutional decline (Turok et al., 2007; Angel et al., 2011; Haase et al., 2013; Raška et al., 2019). The decline

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[1] Original values in US dollars are $136bn, $119bn, and $0.85tn, respectively. Values were converted to Euros using an exchange rate of 1 USD = 0.84 EUR as of 2020.11.09.

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leaves along a number of unused residential and industrial buildings that undergo physical decay and imply environmental, economic, and social degradation of the areas (Rumpel et al., 2010). From an urban design perspective, a commonly suggested solution to urban decline are renewal or regeneration policies to revitalise abandoned sites and enhance local communities, e.g., through the redevelopment of brownfield sites (Pizzol et al., 2016; Bosák et al., 2018). However, such actions often do not consider possible effects on Flood Risk Management (FRM; Haase, 2009) and they, in fact, may induce changes in both local and the city-level patterns of vulnerability and exposure leading to conflicting impacts on flood risk and overall city health. Since the location close to the waterfront was among the main factors in establishing the industries as well as residential zones in the past, there is now a considerable share of the declining sites in flood-prone areas in some old- and post-industrial cities. In this respect buildings that underwent decay and are now intended for regeneration may still amplify hydraulic effects of flood waves in urban floodplains and pose a risk of contamination from polluted sites during overflows, while - in addition - the decline of social, economic, and institutional strength in old- and post-industrial cities also negatively affects the capacities for FRM.

It is therefore important to consider how the urban regeneration and FRM approaches interact with each other. The concepts of integrated FRM and risk governance indicate that a regeneration policy should take potential flooding impacts into account (Haase et al., 2014). This combined policy strategy should aim to limit the potential long-run impacts of operating in flood-prone areas. There are a range of activities that can be employed based on risk avoidance (not developing in flood-prone areas), risk reduction and mitigation (undertaking actions that lower risk to those in flood-prone areas), and risk transfer (financing losses so that those impacted can recover). These different actions have been widely studied in the academic literature. For example, Poussin et al. (2012) and Koks et al. (2014) investigate how spatial planning or adaptation can limit negative impacts. Hudson et al. (2014), Bubeck et al. (2012), and Attems et al. (2020) investigate various ways in which flood vulnerability can be reduced through property level protective measures. Finally, insurance is often considered to be the representative mechanism of risk transfer (Poontirakul et al., 2017; Thistlethwaite, 2017; McAneney et al., 2016; Paleari, 2019).

We argue that both urban regeneration and FRM are complex problems with similar considerations when framed within the concept of zoning. Hudson and Botzen (2019) note that zoning can successfully reduce the impact of flooding on society. The success of policies aimed at changing land-use or spatial adaptation concerns correspond to a spatial turn in flood risk management (Hartmann and Spit, 2014). These policies aimed at limiting flood impacts can alter the rate of development in flood-prone areas, introduce building codes to reduce vulnerability, convert built up areas to nature altering the hydrological outcomes, relocate buildings, and raise public awareness (Botzen et al., 2019; Burby et al., 2001). Therefore, these policies can act on all three elements of the risk equation jointly while boosting resilience as society is better able to withstand flood impacts even if the absolute risk has increased. Moreover, land-use or planning regulations can also have other benefits, for example, by improving the local environment (Hudson and Botzen, 2019). Due to the extensive nature of potential planning regulations, they can also have substantial negative impacts, however. These negative impacts can accrue from placing economic activities in sub-optimal areas, there are costs associated with relocation, increased awareness creates greater senses of unease, or the reinforcement of social inequalities if marginalised groups are not considered during the decision-making process, for example. Moreover, these difficulties and conflicting impacts lead to potential conflicts across different stakeholders within this sphere of operation. For example, Golnaraghi et al. (2020) notes that in both the UK and Germany flooding impacts should be considered when considering new development projects, however political priorities reduce the capability to do so. Slavíková et al. (2019) revealed that in small Czech municipalities similar problems occur.

A potential way of easing this conflict is by considering each element of a development project as providing a range of benefits that outweigh the potential increased flood impacts. These different elements can also reflect relevant priorities as land is not used for a single purpose. Therefore, regeneration projects should reflect these different potential outcomes, while reflecting the range of socio-environmental interactions. One method of doing so is through a cost-benefit analysis (CBA), which is a predominant approach for evaluating decisions within climate and disaster risk management, due to the necessary consideration of where to invest limited funds that have fungible uses.

CBA involves aspects of positivist thinking, however. Allmendinger (2002) argues that planning theory has moved into a post-positivist direction as planning is not a technical process but, rather, is a normative process (Allmendinger, 2002). As such, the methods employed must be placed within the socio-political context in which they are developed and applied. Allmendinger (2002) argues that because of this recognition planning theory has moved towards using conceptual tools that are collaborative and participatory in nature (Rydin, 2007; Dobrucká, 2014; Hartmann and Geertman, 2016). This pattern of evolution shares similarities with the paradigm shift within disaster risk management that seeks to strike a balance between hierarchical and interactive disaster management based on the inclusion of stakeholders and citizens in decision-making (Hartmann and Driessen, 2017; Hartmann and Spit, 2016). The commonality between these two fields is unsurprising given how the process generating disasters is a process as complex as that governing the needs of urban planning. A further commonality between the fields is that “wicked problems'' or complex problems must be addressed as Hartmann (2011, 2012) shows. A wicked problem is a complex problem whereby potential solutions can be defined as one that is "good outcome" and a “bad outcome” based on a normative understanding of potential outcomes. This introduces a large degree of additional uncertainty and complexity into decision-making (Hartmann, 2011). The management of such problems requires a deliberative process, a requirement that both planning and disaster management share so that problems and solutions can be framed, proposed, and evaluated. A CBA is fundamentally a deliberative decision-support tool (Mechler et al., 2014), or as a venue for aggregation and contestation (Hockley, 2014) rather than being the final indication of whether a project or investment should move forwards. This is because it requires active engagement with those who will be impacted to understand what changes are to be valued, whose values get counted and what does not, it involves the transparent description and presentation of what is considered a “good outcome” and a “bad outcome”.

Therefore, while the conceptualisation of decision-making theories and processes appear to be different in planning and disaster management, both are reliant on decision-support tools that should embrace deliberative and participatory processes to make sure that correct normative and social underpinnings and validity are generated. In this vein, Hudson and Botzen (2019) review the literature presenting a cost-benefit analysis of flood risk management zoning policies (i.e., land-use changes undertaken primarily to reduce flood risk). They find a total of six studies focusing on this topic, with a mean benefit-cost ratio of 1.65 growing to 2.2 if only high-risk areas are focused upon. This indicates that these policies could play a useful role in flood risk management. However, the limited number of studies identified by Hudson and Botzen (2019) call for more research to gain a more complete understanding of how zoning policies act as part of the portfolio of FRM mechanisms. Notably, it must be recalled that while CBA is often used to study if an investment or project should go ahead, its true value is as a decision support tool. This is because it forces information to be collected, presented, and evaluated in a systematic manner. Undergoing the CBA process, especially in a stakeholder-led manner, produces a learning process. From this it is possible to develop bridges across the two research communities of FRM research and urban planning, as urban planning is argued to need a stakeholder-led process to underpin its decisions (Rydin, 2007; Dobrucká, 2014; Hartmann and Geertman, 2016).

Within this research context we seek to extend this limited literature. This is achieved by studying a sub-element of an urban planning strategy that is envisioned for the city of Ústí nad Labem in north-west Czechia. Ústí nad Labem is a post-industrial city, facing issues with depopulation and abandonment of several sites. This has resulted in the city and local community developing a vision plan to regenerate the city based on exploiting the potential of several urban brownfield areas. However, several of these brownfield sites are in flood-prone areas producing a potential trade-off to be considered. To construct this initial exploratory analysis, we develop four potential strategies to better understand the policy portfolio available to flood risk managers and urban planners who should jointly act to optimally generate social welfare. Moreover, in conducting an initial exploratory CBA of this policy portfolio we add policy relevance to the findings of this study by highlighting how considering flood risk in regeneration strategies can and should be done as a central element of the development process despite the limitations faced. Therefore, this paper starts from a hypothetical situation as an initial starting point without wider societal engagement as a demonstration of the value of the concept to aid in decision making.

2. Data and methods

2.1. Study area

Ústí nad Labem (Fig. 1) is a post-industrial city affected by structural changes in traditional economic sectors, which is echoed across many regions of Europe and beyond (Krzysztofik et al., 2016; Trippl and Otto, 2009). Located in north-west Czechia, Ústí nad Labem experienced industrial growth becoming one of the industrial cores before the second

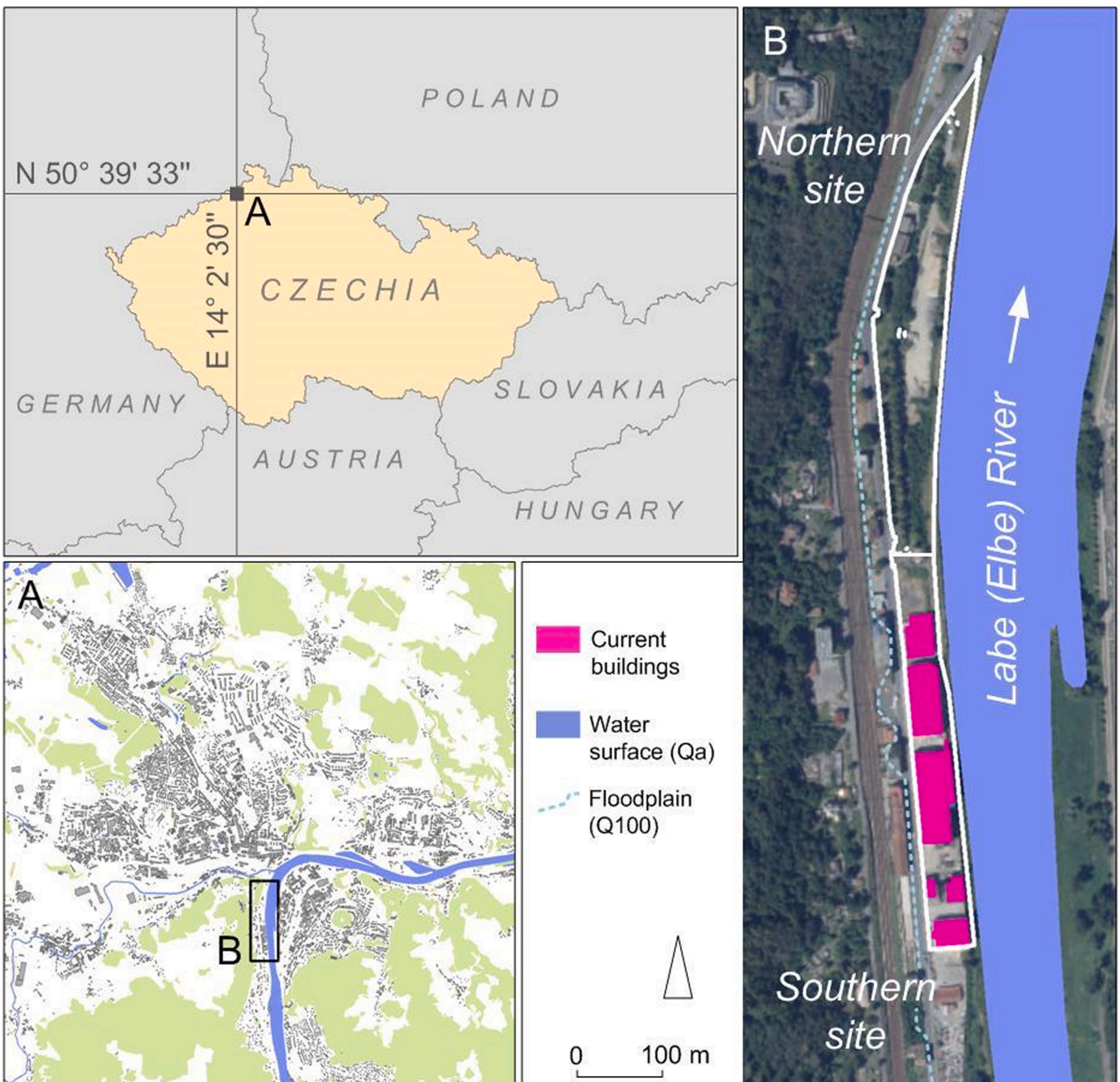

Fig. 1. Location of the study site within Czechia (A) and the Ústí nad Labem city (B).

world war and during the former communist state between the 1950–1980s (Raška et al., 2019). However, the fall of communism in 1989 led to rapid changes, resulting in a loss of 8% of its inhabitants as compared to 1991 census due to a range of negative environmental conditions (e.g., air and water pollution, poor condition of physical infrastructure), the decline of privatised industries (Rumpel et al., 2010), and liberalisation of the labour market supporting migration within the country. These factors have led to the decay of both residential and industrial sites across the city (Raška et al., 2019).

The core study area is an industrial complex on the left bank of the Labe (Elbe) River, which has undergone several different commercial usages and ownership changes. Multiple buildings in the immediate area have remained abandoned for many years. This has a negative impact on their current quality once the threat posed by flooding is accounted for, such as the major flood in 2002 which was felt across a wide part of central Europe (Becker and Grünewald, 2003). To help prevent further decay, the Ústí nad Labem city authority has attempted to attract new investors despite the flood risk potential (Bergatt Jackson et al., 2010; Ústí nad Labem city authority, 2015).

This can be taken as an indication of the relatively low priority that intermittent but potentially devastating flooding is given compared to more immediate and tangible problems in urban planning decisions. While some private companies and officials have declared that there are barriers to development and they do recognise flood risk as a consideration, it is given a lower priority as compared to the perceived benefits of redevelopment (Weissová, 2013). Raška et al. (2019) note that the presence of flood risk should limit the options for the development of the area. This is unless active flood risk adaptation and protection are integrated into any proposed development. In turn, multiple issues should be addressed in parallel rather than fragmented manner.

2.2. New zoning regulations and land-use change for urban regeneration and scenario development

Our aim is to show how urban renewal and FRM concerns can be integrated together through a social CBA. This is because conducting a CBA from the perspective of a socially orientated urban planner, the resulting process seeks to balance the competing FRM and urban regeneration welfare implications. To conduct such an analysis, a comprehensive set of impacts need to be studied so that all the relevant impacts over a relevant time are considered. This is relevant as the CBA attempts to organise and compare positive and negative welfare impacts to determine if there is an overall welfare improvement for society. However, it must be noted that while a CBA analysis should be comprehensive, there are various data and resource limitations. Once the analysis begins some aspects can be better evaluated than others. Therefore, we focus on what can be most reliably worked with as a starting point to indicate what knowledge gaps must be filled. The remaining elements are discussed as a qualitative addition to the monetary focus of this paper to address this trade-off in data quality. As such our study acts as an indicative element of how flood risk can impact regeneration projects as part of the city's wider regeneration vision given the prominence of the Labe (Elbe) river in the city. This can be in terms of how we design the buildings to be developed or if the investment represents a net loss to the city's overall welfare. In doing so, we place the impacts of flooding as a core element of the planning process, which may otherwise be neglected in the favour of more immediate political objectives. This is an important consideration because, at its core, urban (re)development wishes to generate the highest net increase in overall city welfare.

The conceptual basis of our study is a thought experiment, conducted solely and independently by the authors, relating to the regeneration vision of the city government while considering FRM. The regeneration vision reflects the goals of development strategy in the city (Ústí nad Labem 2015–2020). The strategy aimed to redevelop and reuse some of the brownfields to reach a share of 3% of the city, compared to 11.7% in the early 2010s (Ústí nad Labem 2015–2020). Several such areas within the Ústí nad Labem are in flood prone areas. We focus upon one of these potential sites which due to its location alongside the River Elbe can be regenerated as either new/refurbished apartments or as a riverside park area. These avenues are popular regeneration scheme components (e.g., Alpopi and Manole, 2013 or Newton and Glackin, 2014). It is assumed, independently by the authors, that each site action is part of a wider strategy to attract and maintain new residents. Therefore, following our assumptions there are 4 possible outcomes as shown in Fig. 2 combining various degrees of built-up and urban greenery development. This analysis is conducted at a parcel level as there can be optimal patterns for development and FRM when looked at individually (Kousky et al., 2013), which could allow for a more efficient programme overall. This site has been selected as the research team has conducted extensive research on this area of the city in relation to flooding in previous projects. This allows the analysis of the thought experiment driven scenarios to be empirically based on the research team's expert knowledge of the case study area, use of local data, and transferring relevant values from the wider scientific literature (e.g., summarised by Macháč et al., 2019). However, the categorisation and selection of benefits and the assumptions required to drive the analysis were selected by the research team independently of the city government and local community. Therefore, the study provides a starting example of such a project, which if to be implemented must be expanded into a more in-depth participatory process involving local stakeholders and policymakers in the development and further refinement of the normative underpinnings of the study. Following an increasing perspective that both FRM and urban planning needs a large degree of social engagement. However, for our initial scoping exercise this is based on the principle of proportionality and as such is not immediately required.

The rationale for this approach is to model how to consider FRM needs when designing urban regeneration strategies or visions. Therefore, we do not directly include the current status quo situation into the analysis for several reasons. The first is as a simplification of the analysis of a potential sub-set of an overall regeneration vision to raise awareness of the potential impacts and the automatic inclusion of actions against it. While there is a regeneration vision for the city, it is not solidly determined and extends across several parts of the city which have less reliable data and assumptions. Thereby focusing on one future looking aspect of the regeneration vision we can suitably simplify the situation to study with the resources at hand. However, this is at the expense of being truly able to evaluate if such a regeneration vision brings an overall increase in benefits to society. This would require a more comprehensive analysis than our preliminary indicative one. Therefore, we test which combination of developments provides the highest return on the assumption that the project will happen if at least one of the scenarios returns a sufficiently high benefit-cost ratio (BCR). This work can provide the basis of a future more in-depth study of the wider implications of regenerating flood-prone urban areas, within which a wider range of local stakeholders and policymakers must be included. The second rationale is that while there can be guidelines and regulations organising how urban developments can take place, its decision process is still fundamentally driven by local political pressures and concerns. An independent analysis at this step can thus provide new impulses for future development and support the discussion about different options and scenarios. Therefore, we have effectively assumed a positive decision to regenerate but not the direction in which it will develop.

2.2.1. Urban development

We assume that for this project there is a single model apartment that will be developed in both sites to reduce the complexity of the analysis. The Southern site is currently the most developed and sets the pattern for the other site in terms of architectural design and footprint.

Southern site: According to the cadastral records available the entire site covers an area of 21,192 m^2. The site currently contains 6 separate buildings that can be converted. In total these 6 buildings cover an area

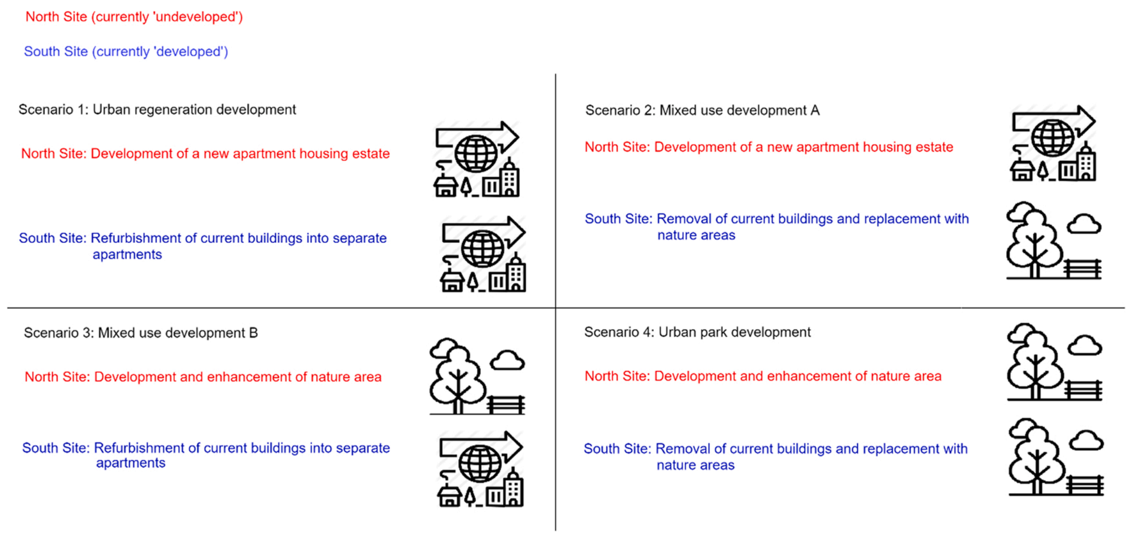

Fig. 2. The four possible regeneration scenarios developed.
(Source: authors).

Type	Item (bold for which we have data, other left for discussion)	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		South (refurbish)	North (develop)	South (nature)	North (develop)	South (refurbish)	North (nature)	South (nature)	North (nature)
(1) The flood risk	**flood impact (tangible)**	-	-		-	-			
	flood impact (intangible)	-	-		-	-			
	saved resources for flood emergencies			+			+	+	+
(2) Building values	**construction (incl. green spaces between buildigs)**		-		-				
	refurbishment (incl. green spaces between buildigs)	-				-			
	demolition			-				-	
	park development			-			-	-	-
(3) Flood-proofing	**flood proof basement**	-	-		-	-			
	windows openings								
	waterproof cellar using bitumen sealing	-	-		-	-			
	AquaFence	-	-		-	-			
(4) Externalities	water pollution	+	-	+	-	+		+	
	increasing pollution from traffic (CO2***, noise)	-	-	+	-	-		+	
	loss of jobs (aggregate economic loss) by turning commercial buildings into flats	-				-			
	image of the area	+	+	+	+	+	+	+	+
(5) Potential multiplier effects of new residents	**aggregate multiplier effect of new residents**	+	+		+	+			
	public services costs (traffic, schools, sewage ...)	-	-		-	-			
(6) Ecosystem services**	**runoff regulation**		-	+	-		+	+	+
	microclimate regulation		-	+	-		+	+	+
	aesthetic value			+			+	+	+
	recreation			+			+	+	+
	biomass production		-	+	-		+	+	+
	biotope formation		-	+	-		+	+	+
(7) Benefits from selling the flats	**sale prices**	+	+		+	+			
	local taxes	+	+	-	+	+		-	

-	A cost item
+	A benefit item
	A N/A item or no change

Fig. 3. Classification of impacts considered; items highlighted in bold are ones that can be quantitatively included in the analysis.
(Source: authors).

of 11,077 m^2. Moreover, each building contains multiple stories (ranging from 2 to 4), increasing the effective potential living area. It is assumed that 85% of the available space on each story can be converted into apartments which are assumed to be 80 m^2 in size on average. This set of assumptions creates an estimated 359 new apartments, with an expected 1076 new residents (on average 3 per apartment). There would be approximately 118 ground floor apartments that are exposed to flooding. This scenario leaves an area of 10,115 m^2 that can be converted into urban park land and other surfaces.

Northern site: This site is bare land that can be developed in new apartments. The total size of the area is calculated to be 33,937 m^2 according to cadastral records. Following the same overall building design as in the southern site, this produces 574 new apartments with 1723 new residents. This leaves 18,872 m^2 available for conversion into parkland or other surfaces. In this development there would be about 188 ground floor apartments that are exposed to flood risk.

2.2.2. Nature development

This development project involves the demolition and removal of any old and partly abandoned buildings currently on the site, followed by an investment in developing suitable parkland. This is based on work developed and presented in Macháč et al. (2018) and Macháč and Louda (2019). In both cases a neglected area in Czechia (in Brno and Plzeň) was transformed into a park. In the case of Plzeň the park was established in a former horticulture area located in a flood-prone area. Four wetlands with flood retention capacity were built in the park, therefore the park provides both recreational and flood protection services (Macháč and Louda, 2019).

2.3. Conceptual approach to benefit classification and inclusion

After the creation of the scenarios, a wide-ranging inventory of all possible benefits and costs from the above projects were considered. Benefits and costs were classified according to their potential social, environmental, and economic impacts. Based on expert knowledge of the area, it was then discussed out of this set of potential impacts, which were the most relevant and plausible that should be considered in the analysis given the specific local context. These discussions lead to the classification scheme presented in Fig. 3. There is a further classification into costs (pink), benefits (green), or not applicable/no expected change (yellow) within a given scenario. Once this set of most important factors was developed, further efforts were placed in discovering which impact categories could be reasonably measured as part of our scoping objective. This was a required step due to a range of data and resource limitations, which meant that only the most reliably measurable impacts should be included in the calculations. These categories are highlighted in bold text. This step was taken as there are open questions regarding whether it is better to provide some number or no number given the inherent uncertainties in the methods and data used to calculate that value. These steps reinforce the indicative nature of this analysis which can be used as a basis of future more in-depth studies or a comprehensive regeneration plans/vision.

2.4. Time horizon and discounting

The central time horizon considered is 30 years roughly matching the expected lifespan of the flood-proofing measures. Due to the time dimension of certain impacts, it is required to discount estimates into a present value (PV). The European Commission recommends a 5% social discount rate for projects in Czechia, while the Czech government uses 4%. We use the more conservative value of 5%.

2.5. CBA calculations

2.5.1. Flood risk and flood-proofing

One way to act upon flood risk through urban planning and land-use management is to limit the generation of new flood risk as much as possible. Therefore, it is assumed that an integral part of any development taking place in flood-prone areas, which cannot be avoided, will have to meet certain protective standards to mitigate flood risk. The adaptive measures considered are structural measures that can be integrated into new constructions, which is often cheaper than retrofitting (Kreibich et al., 2015), and do not have to be actively employed by the owners to prevent damage. The mandated adaptation consists of: Flood-proof ground floor windows openings, waterproofing with bitumen sealings, and mobile flood barriers (i.e., Aquafence). These measures are considered from the review presented in (Attems et al., 2020), and selected based on expert knowledge of what was suitable and available for the site under study. The combination of measures considered, led to the assumption that they successfully prevent all damage from a flood until the flood water height reaches 1.2 m (designed height of the protective measures), after which the measures do not prevent damage due to overtopping. This is drawn from standard assumptions in flood risk management (e.g., Saint-Geours, 2012; Kelman and Spence, 2004; Nadal et al., 2010).

Local data indicates that an inundation height of 1.58 m will be reached with an annual occurrence probability of 1%. However, we do not have clear data upon which the 1.2 m threshold is exceeded. Therefore, we shall assume that it is exceeded with an annual probability of 3% based on the observation that in the past 100 years there have been 3 major floods reported in the study area (Raška et al., 2019) that could plausibly overtop the installed barriers. While climate change is important, we cannot directly account for it in our study due to uncertainties in its effects on overall flood risk at such a local scale.

To determine what flood damage can occur, we consider both tangible and intangible losses. The tangible flood losses (i.e., damage to the building or contents) is based on an absolute value of potential contents and building damage that assumes that once the flood defences have been exceeded a loss of 100 EUR/m2 (Huizinga et al., 2017) is inflicted. Each ground floor apartment is designed to have an area of 80 m2, implying a tangible loss of 8000 EUR. The upper floors are considered as safe from potential tangible flood damage. Intangible impacts are also considered as CBA is based on a utilitarian welfare basis, which means we should aim to account for a range of welfare impacts. This is particularly relevant since floods cause long lasting human impacts in terms of health or emotional impacts, which is a further reason for not developing in floodplains unless it cannot be avoided. However, compared to tangible monetary impacts intangible impacts are more difficult to evaluate and include in a CBA. A starting point for including intangible impacts is from Hudson et al. (2019) who note that in France intangible welfare impacts may have been twice as large as tangible impacts. Moreover, they also find that you do not need to be directly impacted by a flood to suffer welfare losses if you had seen your ground floor neighbours flooded. This impact was valued at roughly one third of the overall welfare impact of those immediately flooded. Therefore, we rescale tangible flood losses to account for this assuming a final one-off impact on the present value of tangible flood risk.

Therefore, when the northern site is developed, the total PV of flood impacts with a 5% discount rate and a 3% occurrence probability is 3,531,580 EUR over 30 years. When the southern site is developed it is associated with a flood impact PV of 2,211,585 EUR over 30 years.

2.5.2. Flood-proofing costs

The flood-proofing costs are based upon Attems et al. (2020). The flood-proofing employed assumes that any new construction in a flood-prone area should have comprehensive packages of measures that aim to mitigate as much flood damage as is physically possible. Therefore, the package of measures included altering windows to be more flood resilient (requiring 4 per ground floor apartment), dry flood-proofing of the ground floor (based on surface area), and employing fences (e.g., based on the AquaFence) around the perimeter

Table 1
Cost structure of the employed package of adaptation measures per site in EUR.

	Developed or converted buildings	
	South	North
Windows (1 per window on the ground floor)	450 x (118 ×4)	450 x (188 ×4)
Sealing ground floor with bitumen	465.10 x (9415 m2)	465.10 x (15,065 m2)
Flood-proofed walls	350 x (582 m)	350 x (737 m)
Total cost	4,849,267	7,603,082

Notes: calculations are as follows – (cost per unit of the measure) x (number units per flat required or surface area required).

of the building.

The estimated cost structure is presented below in Table 1. These costs assume that each window on the ground floor will be protected, as will the entire surface area of the basements, and a flood resilient walled perimeter for each site. This package is required to correctly simplify the flood risk aspect of this study, into its binary situation for it to be trackable for the analysis.

2.5.3. Building values

New construction: The value of construction is determined as the product of the following values. The total size of the area in metres; the 2020 average building costs (without profit margins) per 1 m^2 for recently constructed/designed similar flats included other costs e.g., parkland (i.e., 2015–2019) in 3 Czech cities multiplied by 80 (the size of the apartment).

Refurbishment: This is determined by taking the number of potential apartments and multiplying it by the size of the apartments (80 m^2) and the average price of new apartments (new construction) and multiplying it by coefficient of addition costs 1.4, which is the average value of the additional costs of refurbishment in comparison to new build construction costs. The additional costs of refurbishment are about 25–50% of the new construction in Czechia, and in comparison to similar projects these costs are about 40% higher.

Demolition: The total area of the building was multiplied with the average cost of demolishing a building per 1 m^2. This was calculated by taking the average cost as presented in Pomajbíková (2012) and Kvasnica (2017), and then adapting this cost to the buildings currently present at the site.

Park development: This is determined by taking the product of the total area of the converted to park land and similar surfaces in the targeted site and multiplied by the required investment per m2 as identified for a similar project in Macháč et al. (2018) and Macháč and Louda (2019) See (Table 2).

2.5.4. Potential externalities

There are several potential externalities that could occur (outside of changes in flood risk). The most important potential externalities identified are water pollution; increased pollution from traffic (e.g., CO_2, noise), change in employment, alterations in the area's image outside of the ecosystem services altered.

These factors are important to consider, but we were unable to reliably estimate or evaluate them. Therefore, they have been excluded from the monetary analysis, but they will be considered in the qualitative considerations section. The change in the area's image, however, is a relatively more nuanced aspect. This is because this paper is conducting an indicative analysis of a sub-element of an overall regeneration vision, which changes the image of the city. Hence, part of the focus on introducing nature or park areas where possible as part of these developments. The ecosystem services that provide at least one aspect of this policy are indicated below. Though, wider changes are left to qualitatively understand.

Table 2
Construction values for the possibilities across the two sites in EUR.

	South site	North Site
Construction (incl. green spaces between buildings)	n/a	53,096,577
Refurbishment (incl. green spaces between buildings)	46,568,519	n/a
Demolition	2,286,962	n/a
Park development	149,430	239,299

2.5.5. Multiplier effects

In scenario 1 there is a potential influx of nearly 3000 new individuals divided into 933 households to the area, who are assumed to migrate into the city from elsewhere in the region. In 2018 (before the covid-19 pandemic) the average consumption expenses of Czech households were on average 371,223 CZK per year (CZSO, 2019) or about 14,300 EUR per year. This potentially presents a large boost to spending within the local economy of Ústí nad Labem city, of potentially about 13,321,205 EUR if 100% of this new consumption spending is spent within the city and both sites are developed. This in turn could create a new surge of business and employment opportunities across the city to best exploit this new opportunity. However, information on potential multiplier effects from this expenditure are uncertain and depend on many new aspects of the local conditions and can therefore be hard to transfer from one region to another. Therefore, we limit our analysis of this aspect by only considering what happens if 50% of this new potential consumption expenditure was spent and remains within the city and can be considered as a direct benefit within the presented framework. We undertake this simplified approach because while there is a limited literature on the value housing development multiplier effect, it is a complex value that requires knowledge of economic growth within its wider cycle, density of population, consumption patterns, how income remains in a city (e.g., see Ladd, 1994 for a discussion). Therefore, we elect to keep it simple as providing information on many of these topics is beyond our scope. Moreover, using existing multiple values would require a value transfer argument, which requires we take such a value from a similar area to Ústí nad Labem. Otherwise, the inherent uncertainty and resulting measurement error would reduce the usefulness of the value used.

However, the new influx of people and the economic potential they represent also requires additional infrastructural development. The main avenues required are a potential increase in schools (at all levels). The largest expenses not already included in the construction costs that can be reliably estimated are that new bus stops and public transportation will be required (estimated at 0.6 million CZK; 23,076 EUR) and an expansion of local pre-school facilities estimated at 0.5 million CZK per year per child (19,230 EUR). If the local population's age structure remains roughly intact as at the start of the project, there would need to be suitable places for about 82 new children between the ages of 3 and 5. This produces a PV cost of 15,562,571 EUR regarding the northern site, and 9,664,871 EUR for the southern site.

2.5.6. Ecosystem services

Based on expert knowledge of the area the following ecosystems services were considered as the most relevant, as shown in Table 3: runoff regulation (bringing an annual benefit); microclimate regulation; aesthetic value (considered as a one-off benefit); additional recreation benefits; annual biomass production; biotope formation. Out of these core ecosystem services considered only two can be reliably calculated: runoff regulation and aesthetic values.

Annual runoff regulation influences flood risk as it affects the drainage potential of the area. If the area helps to attenuate runoff, it may help to minimise the impacts of flood events. Natural areas positively influence runoff regulation and provide positive ecosystem services for the CBA, while developed areas due to the presence of sealed services usually worsens the runoff regulation potential of an area and represent a negative impact on runoff regulation potential. Our core assumptions in estimating a value for this ecosystem service are as

Table 3
Ecosystem-service valuation for the possibilities across the two sites in EUR.

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	North	South	North	South	North	South	North	South
runoff regulation – annual (Converted into present value)	-32,771	0	-32,771	+54,131	+30,760	0	+30,760	+54,131
aesthetic value - one time	0	0	0	+2,654,820	+2,328,426	0	0	0

follows: no green roofs, no usage of rainwater in houses for example for toilets etc; all unevaporated, un-infiltrated rainwater goes into the rainwater sewer. We then used the approach presented in Macháč and Louda (2019), which is that a value can be produced by assuming that water from these roofs is valued at 10 CZK/m^3.

For the aesthetic values, it is assumed that its value occurs when a nature area is located next to an urban development. Therefore, this value occurs in scenarios 2 and 3. Therefore, it is assumed that it is an effective surcharge of 5% of the value of the neighbouring developed area. This represents in effect the expected PV of nature benefits. This is likely to be an underestimate of the aesthetic values as there is the potential for the entire city to enjoy the amenities provided. However, in our limited application, this source of uncertainty may be reduced because of the relatively limited area converted and its location within the wider city.

2.5.7. Benefits from selling a property

One of the main benefits from developing property in a former brownfield site is the potential income from selling the newly developed property. From the perspective of the social planner and developer, there is the one-off benefit from the sale of the property and the on-going generation of local property taxes.

Property sale values can vary dramatically property to property, time of year, economic conditions (e.g., significant increase during the covid-19 was observed in Czechia), etc. However, from multiple sources we can assume that a plausible range of values is between 17,000 and 35,000 CZK per m2 (654–1346 EUR). Therefore, to account for this uncertainty these values will be used as the mid-point of these estimates (999 EUR).

In terms of the total taxes per year, this can be estimated as 4 CZK / m^2 for each property owner, while the parcel tax per year is 2 CZK / m^2 paid annually for built-up and non-built-up parcels by ownership corporations. Therefore, it can be assumed that this is a total tax revenue of 6 CZK (0.23 EUR) per m^2.

For both categories, we assume that new developments will be sold and occupied for 30 years. This produced a total value of 45,897,892 (North) and 28,692,613 (South).

3. Results and discussion

3.1. Results

3.1.1. Quantitative outcomes

Once all the relevant costs and benefits for a given scenario have been converted into their present value (PV) in constant EUR values, we can aggregate them to produce a benefit-cost ratio (BCR) for each site for a given scenario, and the scenario overall. The outcome of this quantitative outcome is presented in Table 4.

In terms of costs the largest source of costs is the construction of the buildings at about 85% of total costs quantified, while the net-flood loss and adaptation costs account for the remainder. Flood costs in this respect are the smaller contribution because of the degree to which the mandated precautionary measures are in relation to the expected flood depths and occurrence probability. The largest source of benefit is the expected influx of consumption expenditure. Therefore, a core step forwards will be to better understand how the influx of new residents will create economic ripple effects throughout the city.

The best scenario is the one with the highest average BCR across both sites if both are at least 1. Therefore, from the values presented in Table 4 it appears that the mixed development scenario 3 is the most appropriate as it generated the highest parcel average BCR, standing at 5.49. This is where the northern site is developed into a nature park, but the southern site is refurbished once the buildings have been sufficiently protected against flooding. It is judged as the average Parcel BCR rather than the sum of the total benefits as compared to costs of a scenario because of the quite different scales of the investment across the development subsets. Table 4 indicates that for scenario 2 the nature action costs is only 3% of that of the development costs with a similar ratio of benefits, for example. Therefore, if the scenarios were considered purely as a sum across the sub-elements, the numerical gravity of the development scenario would dominate. Therefore, we argue that it is wiser to look at the average BCR to account for this. A further relevant consideration is that it must be noted that the unrounded BCR of the Southern site is slightly higher under Scenario 2 than 3 (1.112 vs. 1.106) even if they round to roughly the same number. Therefore, once the potential uncertainties and limitations are considered, the difference between refurbishing or naturing the southern site is unclear. Unless it is considered in relation to nature benefits provided by not developing the northern site which is currently relatively undeveloped and should remain so. Therefore, the implication for urban renewal in this case is that a flood-prone developed brownfield site might be better suited to redevelopment and suitable retrofitting when neighbouring less developed brownfield sites are converted to nature areas. However, the individuals who move into the area, would also be required to be made aware that they are at risk to make informed decisions.

We further explore what degree of changes would be required to change the BCR's above 1 to below 1, as listed below, to act as a sensitivity analysis:

- Developing the northern site: For the BCR to become smaller than 1, it requires one of the following changes: only 26% rather than 50% of consumption expenditure to remain within the city; Flood risk to increase by 1000%; Construction costs to increase by 60%; Adaptation costs to increase by 420%. Overall, these factors are rather

Table 4
Overall cost-benefit analysis results in constant EUR (rounded to two decimal places).

	Northern site			Southern site			
	Aggregated PV of Costs	Aggregated PV of Benefits	Benefit cost ratio	Aggregated PV of Costs	Aggregated PV of Benefits	Benefit cost ratio	Average Parcel BCR
Scenario 1	79,826,580	112,039,716	1.40	63,294,242	70,060,060	1.11	1.26
Scenario 2	79,826,580	112,039,716	1.40	2,436,394	2,708,960	1.11	1.26
Scenario 3	239,299	2,359,186	9.86	63,294,242	70,060,060	1.11	5.49
Scenario 4	239,299	30,760	0,13	2,436,393	54,131	0.02	0.08

extreme changes in our estimates and as such are unlikely to occur overall. The most plausible is the alteration in property prices if we assume that not all the properties are sold. However, this concern can be somewhat mitigated by noting how the sites are part of a wider regeneration scheme to make the city more attractive to new residents and investments (e.g., a high-speed train station linking Dresden and Prague).

- Converting the northern site into park land: For the BCR to become smaller than 1, it requires one of the following changes: Construction costs to increase by 980%; ESS value falls by 90% both values are unlikely to occur if the southern site is developed into new apartments.
- Developing the southern site: For the BCR to become smaller than 1, it requires one of the following changes: 42% rather than 50% of consumption expenditure to remain within the city; Flood risk to increase by 400%; Construction costs to increase by 14%; Adaptation costs to increase by 130%; Property prices to fall by 45%.
- Converting the southern site into park land: For the BCR to become smaller than 1, it requires one of the following changes: Construction costs to increase by 170% or ESS value falls by 10%. These are plausible if the northern site is not developed into new apartments.

It can be argued that the most sensitive element is the increased economic activity due to the influx of new residents. This in turn is dependent on the actual demand for the new apartments – local expertise indicates that there are not too many new housing projects in the city. Therefore, the development of nearly 1000 new apartments in this area is rather ambitious. However, it must also be kept in mind that this project is only a sub-element for a wider regeneration vision for sites comprehensively across the city.

In addition, there are costs that were excluded from the analysis, due to uncertainties in calculating the total values required. First, these include the cost of purchasing the sites, because of complicated ownership structure, including both public and private lands of different entities. Therefore, we hypothesised initial conditions in which the city is the owner of all the land and will be the initiator of the public-private partnership. Another cost not calculated was related to eventual loss of jobs by turning current companies in the southern site into apartments. However, the companies currently located could be relocated elsewhere in the city. But as noted in the southern site sensitivity analysis, this is likely to render the urban development scenario not cost effective. This is less likely for the conversion into park land. Finally, we excluded costs and benefits, the calculation of which consist of high uncertainties compared to their contribution to total costs and benefits (e.g., expenditures on flood emergency response, image of the area, recreation, and some of the ecosystem services).

3.2. Discussion

3.2.1. Implications for floodplain development

Current old- and post-industrial (shrinking) cities frequently face the dilemma between urban renewal addressing the demands for economic resilience and social well-being, on one hand, and coping with uncertainties inherent to climate change-related risks, on the other (Raška et al., 2019). Since these challenges are intertwined and manifest high complexity, there also exist multiple trade-offs between measures considered to address these challenges. This is illustrated by the ongoing debates on environmental policy integration which show that many policies remain in sectoral silos and follow their specific goals, e.g., Aubrechtová et al. (2020). In this paper, exploratory CBA was applied where urban brownfield regeneration and FRM strategies clash in the visions of various stakeholders. We developed four scenarios that allowed for comparison of both uniform and multifunctional land use in the study area. Our results indicate that improving the initial conditions at each of the sites within the study area (i.e., combining regeneration of the present brownfield in the south and the enhancement of existing urban greenery in the north) is a more viable scenario than overall regeneration and further housing development, or than turning the whole area into a floodable urban park. This shows that under certain circumstances, involving existing premises where ecological burdens, emerging environmental risks, or increasing downstream flood impacts are negligible, limited floodplain development may represent a legitimate planning approach. It should also be noted that the current demand for land (European Commission, 2016) puts forward a salient need for spatial decisions about housing development and water retention. Given the limited space for flood water retention in urban areas, our research shows that combined urban renewal may be a suitable approach to spatially refocus building activities from peri urban and suburban areas that can be instead kept for water retention. In this respect, our research provides a more varied image and economic evaluation of the possibilities to implement interim land uses (Haase, 2009) or floodable land (Liao, 2012) to support urban FRM.

The above is only a valid trade-off when buildings are suitably protected against flooding. Therefore, if development or regeneration cannot be avoided it is a necessary criterion to protect the buildings to a high degree and maintain awareness and information to avoid the development of a safe development paradox (Slavíková et al., 2021). While there is a debate between private and social responsibility within climate change adaptation (e.g., see Lucas and Booth, 2020) the increasing behavioural focus within FRM (Kuhlicke et al., 2020) means that regeneration activities such as this require that all actors part of the risk chain work together to limit risk proactively while increasing the health of the city in an integrated manner. We should also have continued support for these people so not only do they have access to affordable insurance but also, they are sufficiently prepared for emergency actions. None of the stakeholders should be able to see this as a situation where their responsibility is seen to be abrogated and flood risk is in fact the domain of another actor given how multiple actors interact to generate flood risk.

How responsibilities are considered and allocated also leads to a range of social justice issues that must also be considered at the intersection of FRM and urban regeneration. It can be argued that the purpose of urban regeneration is to create a more attractive city environment, to bring new resources into the city or to stem the outward flow. This, on the other hand, could be considered as gentrification. Gentrification is a contentious issue in many cities due to social (justice) conflicts it inspires. However, the gentrification of areas currently developed while increasing total flood risk through higher value properties potentially brings wider benefits to a city that may require it, to help offset existing wider negative trends. Though to some extent the growth in risk is minimised as new areas are not developed. Additionally, a commonly held position is that the socially vulnerable suffer disproportionately large impacts during a flood event because of how structural inequalities render them less able to adapt, exposed to relatively higher risks, etc. It can be argued that gentrification can undo several social vulnerability issues, due to a more socially advantageous group locating in limited areas of the floodplain that would otherwise be occupied by the socially vulnerable. This changing social power dynamic could be used over time to create an improvement in resilience, while not a one-to-one concept, as socially dynamic groups demand better FRM, risk transfer mechanisms, are better able to absorb impacts, etc. Therefore, while gentrification offers the potential for the absolute value of flood risk to increase, the changing social composition may also increase social ability to accept and manage the risk that is generated rather than a new source of unexpected vulnerability being developed.

A related social justice concern regards how the costs and benefits of the regeneration project are distributed. For example, from the perspective of the city it does make sense to invest money and time to support this project in terms of income flowing in and out of its coffers. The benefits for the city materialise indirectly and as such it could be difficult to rationalise the direct support required for indirect/intangible rewards. Similar argumentation can be made in terms of the citizenry as well who will pay for this investment which will directly benefit people migrating from outside of the city. This is a conflict that needs to be managed before starting the project to rationalise why it is required and the potential benefits, while maintaining the opportunity for the communities to be seen, heard, and influence how this project should go forwards. This is particularly important, as the solutions developed to address such complex problem can be "Clumsy". A clumsy solution is one where one outcome may be worsened, while other outcomes positively benefit (Hartmann, 2012; Hartmann, 2011). Additionally, within a climate change framework this could be referred to as a maladaptive outcome. Maladaptive outcomes are where actions taken to limit risk today, lead to higher risk in the future (IPCC, 2022). In respect to the presented problem of planning for urban viability and disaster risk management, the initially proposed suggestion appears clumsy. This is because a trade-off in increased flood risk for the wider benefits of the city is presented. This is potentially maladaptive from the perspective of disaster risk management as compared to the status quo because more development is taking place in a flood-prone area (though it represents more intensive use of land currently in use). However, in a wider perspective it is a "clumsy solution". The proposed regenerative strategy is aimed primarily at other (non-flooding) problems the city faces. This can prevent brain and resource drains and an increasing fragmentation of the city. In the long-run, this can allow the city to gain the resources needed to open its wider activities to be climate proofed and protected, in the hopes of preventing larger problems from being created through the absence of resources. To conclude, short-term ad-hoc solutions to immediate problems are required before more long-term climate proof-planning can occur. Yet, this implicitly assumes the fungibility of disaster risk management and urban planning outcomes in the minds of those impacted.

3.2.2. Methodological limits and recommendations

The application of CBA in our study has also its limits resulting from the multiple uncertainties in the data used and in future development itself. First, these consist of aleatory uncertainties denoting the probabilistic variability in effects of future climate change as well as economic developments, both affecting the flood risk and the social and economic demands for the use of this site. Climate change is likely to change the frequency, magnitude as well as timing of floods in the area. Because specific manifestations of such change depend on complex interaction outside and within the catchment, the effects of climate change were omitted in the analysis. Uncertainties also relate to the temporal aspects of flood risk impacts (e.g., wellbeing impacts that may persist for several years, and health impacts developed after an event), that the apartments may be sold slowly after construction rather than before completion, which have been ignored as have indirect impacts (e.g., greater economic interruptions if people cannot go to work or public transport is disrupted). We understand these impacts as stochastic because they depend on future exposure of people and elements to individual floods, i.e., mostly on unpredictable complex circumstances within the societal systems. This uncertainty cannot be dealt with without a wider and more detailed understanding of what is happening in the area and without further refinement of integrated socio-hydrological-economic modelling. However, such modelling approaches will have their own additional limitations and challenges which need to be addressed (Blöschl et al., 2019; Bretschger and Pittel, 2020; Di Baldassarre et al., 2019). A possible framework to address this is agent-based modelling (Aerts, 2020) and robust longitudinal data collection.

This leads to the epistemic uncertainties related to lacking or inaccurate data or methodological approaches as touched on above. First, there are conceptual limits as we did not perform an overall analysis of how the entire regeneration vision interacts with flood risk for the city. This requires additional research to capture any strategic changes. However, it is still useful to study individual land parcels to provide a starting point. It shows the overall cost-benefit relations of the development vs. conservation projects in flood risk areas at which (partly) abandoned buildings or brownfields can evolve in both directions. Among the lacking data, the indirect effects (e.g., ecosystem services) and multiplication of the economic effects of newcomers/new apartment buildings is difficult to assess - from existing studies (e.g., Tomal, 2019; Nowzohour and Stracca, 2020) it is clear that context significantly matters (e.g. phase of the economic cycle, level of unemployment). Also, the demand for new housing by newcomers is not easy to predict as it depends on a complex set of push and pull migration factors. Costs of additional public services that need to be delivered to newcomers is difficult to assess - in our paper we have not calculated costs of additional public transport, waste collection, police, enhancement of water supply and sewage. These costs and benefits must therefore be evaluated qualitatively. In addition to the lacking data, there is an extent set of data that are generally available (e.g., flood hazard maps indicating water depths, price maps for housing), but their application through CBA in a specific setting reveals important mismatches in their spatial resolution.

The research thus shows that mostly indirect data are difficult to obtain, but it also revealed that the data that are apparently well available and accurate are not present in a detail and structure that would fit the needs of CBA. Consider for example the state of flood risk knowledge in the study area. Therefore, if CBA is to become a standard tool supporting planning and decision making, the focus should be not only on monitoring a broad set of data, but also on their standardisation and the clear presentation of how this level can be achieved. This is particularly important because land-use planning and urban regeneration strategies are predominantly the province of city governments, while flood risk management duties and options are rather imposed from the central government to a municipal level. This can create a conflicting perception that the capability to develop such models and approaches is beyond the capacity of a city. This is not an ideal situation given how (especially urban) flooding is intensely local. Therefore, the capacity of a city government to make decisions involving the mitigation, reduction, or generation of flood risk on its own must be increased. One often called for suggestions is the development of national platforms that can readily help cities to develop the data and expertise needed, either through collaboration when requested or through 'off the shelf approaches' to help cities do a much more detailed analysis. This can be particularly important in shrinking old- and post-industrial cities which may not have an internal situation that allows for such processes to be developed. Therefore, developing an external platform that focuses on data comparability, shareability, and documentation may enhance the potential to successfully act.

Given the inherent uncertainties within the data and the resulting numbers, it needs to be emphasised that CBA should be understood as tool that can be used as part of an explanatory model helping planners and decision-makers to understand complexity and trade-offs among the factors and components rather than a pure number that independently determines policy outcomes. This has been highlighted by Hudson and Botzen (2019) who stated that wider application of CBA evaluation of zoning policies can bring better understanding of their total impacts. Without such (even not comprehensive) calculations, the zoning decisions in areas potentially affected by flooding might both: increase flood risks or aim at strict conservation of areas with the highest economic value. Despite the data uncertainty, the conclusions derived from the Czech case study show what are the trade-offs between development and conservation of floodplains from the perspective of an urban renewal and site development. Therefore, undergoing the CBA in a participatory manner can help understand priorities and new knowledge directions that need to be filled. As such a possible consideration is that it can be an on-going process, the first step of each is an exploratory analysis to understand the required inclusive decision-making process which in turn indicates where a more comprehensive analysis can more strongly focus upon.

4. Conclusion

Urban FRM and urban planning/development are both complex topics that interact with one another. In some ways regenerated urban areas improve flood resilience and allow society to better weather potential flooding, while at the same time increasing the threat posed by flooding to society. Therefore, rather than fragmented or ignored governance strategies there should be a deeper integration of the two.

This study sought to provide an initial indicative CBA of a sub-element of a regeneration strategy that focuses on flood-prone areas to act as a model upon which a more in-depth analysis of an entire regeneration plan can be based upon. This is a required step in how we approach both urban planning and development as well as FRM. Both seek to enhance wellbeing in a city but interact with each other, as how we design a city impacts flood risk and flooding in turn determines how a city will be used. However, our approaches tend to be fragmented across different governance actors with different priorities that tend to see flood risk ignored as a concern as compared to more tangible developmental returns.

In this light, we present an analysis of an aspect of a larger regeneration vision in a Czech city, that seeks to regenerate several flood prone areas. In doing so we found out that a mixture of urban and nature development projects likely will develop the highest returns if the developed buildings are comprehensively protected against flooding as part of their architectural design. Mixed development projects help to simultaneously further green cities while also refocusing urban extension from peri urban fringe to the inner city itself. This may not only help enhance urban regeneration but will also help to mitigate a range of climate change impacts at a catchment scale. The mixed developments provide a more nuanced insight of the possibilities to implement interim land uses in old- and post-industrial sites. It is important to note that the empirical findings of this paper do not completely indicate that development should always take place in floodplains, even if as a mixed development. Rather, where development already exists or cannot be removed, or where it cannot be avoided a detailed analysis of the potential impacts must be considered under the assumption/requirement that the buildings are suitably protected against flooding and that the community are adequately aware of this risk. These actors must then carefully consider if this is a potential burden that they wish to bear. In demonstrating this, we argue that however “clumsy” the proposed planning solution is, it can only be viewed as maladaptive when solely looked at from a single perspective within FRM. We argue that rather the solution could also be seen within the context of a city requiring regeneration as a required trade-off to allow the city to revolve and stem a flow of resources (e.g. financial, natural, human) that could prevent later adaptation to a range of climate impacts. This is seen through the importance of the degree to which the consumption expenditure of newly incoming residents remains within the city to act as an economic multiplier, for the BCR$>$ 1. Cities in a similar position to Ústí nad Labem can be found across Europe and beyond as various social and economic transitions take place. We emphasise that FRM is undergoing a similar paradigm shift now to what urban planning has already undergone - since flood risk is the product of human choices and land-use decision making, the FRM should be better integrated with the urban land use policies.

In terms of the methodological advancement, we admit that the validation of this study will require a more extensive project involving more substantial participatory co-design with a wide range of stakeholders within Ústí nad Labem. However, while the knowledge on how to integrate the currently fragmented governance approaches exist, our results highlight that the data and expertise for a given city may not be sufficient to conduct a comprehensive analysis. Therefore, we suggest that facilities and platforms to provide this expertise and data must be actively developed and coordinated to reduce the hurdles facing city planners in integrating detailed flood risk knowledge into their approaches. In this respect, we conclude that despite using a monetary (positivist) stance, CBA rather provides a normative and deliberative approach supporting city planners, water authorities and the public in their communication and decisions. When approached from FRM normative point of view, it creates a predominant focus on how any increase in risk should be avoided and where possible limited resources for risk management should be allocated based on CBA. Urban planning takes a wider perspective on meeting multiple polycentric needs and trying to make and find suitable trade-offs between different land-use outcomes and perspectives. This urban planning perspective is an important concept to transfer to sectoral planning efforts (such as FRM) especially within sectors where the concept of resilience as a holistic and multi-faceted concept is growing. Therefore, this paper takes steps towards expanding our knowledge and understanding of the CBA of land-use planning decisions for FRM (a very limited literature). While at the same time as helping to bridge sectoral planning (e.g., FRM) and urban planning (e.g., urban regeneration) with the help of CBA as a decision support tool as a promising approach to provide a common language and scope for stakeholder interaction and contestation.

Data Availability

Data will be made available on request.

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