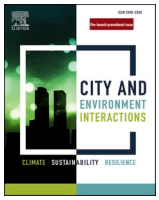
City and Environment Interactions 17 (2023) 100093

Contents lists available at ScienceDirect

City and Environment Interactions

journal homepage: www.sciencedirect.com/journal/city-and-environment-interactions



Promoting a city-river balance within neighborhoods in transition along the Rhone

Sara Formery *, Martine Laprise, Emmanuel Rey

Laboratory of Architecture and Sustainable Technologies (LAST), Institute of Architecture and the City (IA), School of Architecture, Civil and Environmental engineering (ENAC), Ecole polytechnique fédérale de Lausanne (EPFL), BP 2225/Station 16, CH-1015 Lausanne, Switzerland

ARTICLE INFO

Keywords:
Rhone
Sustainable neighborhoods
City-river balance
Project-based vision
Research-by-design
Multi-criteria evaluation
Decision-support tool
Transition
Resilience

ABSTRACT

Relationships between cities and their waters have always been evolving. In a context of transition towards sustainability, finding a balance between the urban and river spaces may contribute to the development of new resilient neighborhoods. To that end, a tailor-made multi-criteria evaluation method appears necessary to gather information not only on sustainability performances of neighborhoods projects but also on specific features linked to a balanced relationships between rivers and cities. On these observations, we develop the concept of city-river balance by focusing on the Rhone territory. It serves as a basis to design an innovative decision-support tool for comparing forward-looking visions for rhodanian neighborhoods in transition. First, this paper presents the methodological research approach taken to develop the tool. Then, it explains the structure and functioning of the tool, followed by a test application to a case study, the Jonction sector in Geneva, Switzerland. Preliminary results show that specific city-river balance components and indicators can explicitly be thematized and measured. Moreover, such a tool could unveil hidden potentialities and help stakeholders to make informed-decision through a resilient vision for the regeneration of rhodanian neighborhoods. In that sense, it promotes not only a transition towards sustainability but also the emergence of a city-river balance.

Introduction

Evolution of the city-river relationships

While the relationship between human settlements and rivers is part of a centuries-long history, the occupation of urban riverbanks has gone through diverse cycles of appropriation and abandonment [1–4]. Once the birthplace of several European cities, then the ideal location for industries, some urban territories close to riverbanks have gradually suffered a decline during the post-industrial era. The dilapidation and obsolescence of many productive sites led to the appearance of brown-fields [5]. Meanwhile, riverbanks in cities are still often bordered by urban infrastructures such as railways, roads, or parking lots. It results in a disconnection of urban river sites with the city centers and degradation in terms of uses and spatial quality [6].

Nowadays, against the background of increased awareness on climate and ecological issues, we observe a significant evolution of the city-river relationship, where new dynamics are emerging. In a perspective of transition towards sustainability, processes of urban regeneration and watercourse renaturation aim to experiment with principles of cohabitation, adaptability, symbiosis, and resilience. [7–10]. In Europe, the phenomenon concerns both large metropolises and smaller municipalities, which see within the reinvention of their urban banks the opportunity to regenerate large portions of their already urbanized territories. These interventions frequently favor major redevelopment of public spaces, integrating new practices related to sustainability issues and new uses for the urban quality of life. Projects of this type often crystallize strong expectations from the population, which highlights the richness but also the complexity of these operations [6].

Thus, the combination of flood protection measures and policies to fight urban sprawl reveals strategic sites located along urban rivers that could be suitable for new uses, particularly when connected to public transport networks and presenting a potential for urban regeneration [11,12]. Although this type of operation allows simultaneously considering a transformation of the city shoreline and the creation of a new sustainable neighborhood, finding a balance between urban intensification and fluvial features is not a spontaneous process. Beyond the questions specific to technical and territorial measures, multiple landscaping, urbanistic and architectural issues challenge the project

* Corresponding author at: EPFL, ENAC, IA, LAST, BP 2 227/Station 16, CH-1015 Lausanne, Switzerland.
E-mail address: sara.formery@epfl.ch (S. Formery).

https://doi.org/10.1016/j.cacint.2022.100093
Received 13 October 2022; Received in revised form 24 November 2022; Accepted 24 November 2022
Available online 26 November 2022

approach to adopt, to inscribe better the city-river balance in the design of these new sustainable neighborhoods.

Need for a tailor-made support tool

The transformation of abandoned or underused river sites into sustainable neighborhoods represents an opportunity to reconcile the inward densification of the built environment - when there is no risk of flooding - with the quality of the natural environment. The integration of sustainability objectives into the regeneration process must go hand in hand with the accentuation of the specific city-river dynamics [13]. It implies the implementation of innovative and integrative approaches, likely to federate a diversity of actors – researchers and practitioners - working in various urban fluvial territories (architects, urban planners, geographers, engineers, municipalities, operators, …), around a shared cultural imaginary linked to living near water [6]. To handle this complex objective, it is essential to act on the basis of sound information and to put a system in place to collect it as appropriate [14]. This consideration, embedded in the concept of sustainable development [15], translates into multi-criteria evaluation approaches [16].

The use of multi-criteria evaluation is a strong trend in urban projects, especially since the apparition of the Sustainable Development Goal (SDG) 11 – Sustainable cities and communities – of the United Nations 2030 Agenda for Sustainable Development [17,18]. It is almost common practice in new neighborhood developments wanting to participate in the sustainability of the built environment [19,20]. The multiple benefits of integrating a multi-criteria evaluation approach in project dynamics are now largely recognized [16,21,22]. A multi-criteria evaluation serves as a support tool at the heart of an informed decision-making process and an overall high-quality approach [23].

Multi-criteria evaluations aiming to assess urban sustainability can take various forms, with a highly variable degree of applicability and exhaustiveness (certifications, checklists, technical guides, evaluation frameworks, rating tools, classification systems, life cycle analysis tools (LCA), etc.). An abundance of them is already available [24], notably at the neighborhood scale [19,20]. We also identify a number of evaluation approaches in the literature that address the relationship between cities and water [25–29]. However, these approaches are often limited to specific aspects such as ecosystem considerations or addresses different topics such as harbor redevelopment or coastal areas. In addition, the context differs and, consequently, the environmental, ecological, energetic, and economic issues as well as the socio-cultural and governance structure vary considerably. To meet expectations, it is argued that a multi-criteria evaluation must take into account a set of parameters, such as the appropriate choice of indicators and the specific context [30,31]. In other words, a tailor-made tool sensitive to the type and context of the project appears to be the only way to face complexities, ensure a certain rigor and credibility of the results, and provide decision-makers (designers as well as authorities) with a real account of a given situation [32–34]. In that sense, the proposed tool would be a multi-disciplinary design support, but not a design assistance tool.

Research objectives

The work presented in this paper is part of the *Rhodanie urbaine* research project, which focuses on urban territories along the Rhone [35]. Based on the above considerations, we introduce here a tailor-made multi-criteria evaluation method specifically adapted to issues raised by the development of sustainable and resilient neighborhoods near the Rhone. According to SDG Goal 11 "Make cities and human settlements inclusive, safe, resilient and sustainable" [36], not only the concept of sustainability but also the one of urban resilience – understood as the capacity of resisting, recovering, adapting, and transforming [37] – deserves to be developed and deepened to address future fluvial neighborhoods issues [38]. It takes the form of a decision-support tool divided into two sets of indicators. On the one hand, it is structured around environmental, socio-cultural, and economic sustainability indicators [39]. On the other hand, it offers a comprehensive set of indicators related to the city-river balance [40].

Our investigations revealed that the regeneration of rhodanian sites presents similar issues in terms of territorial planning but also different contextual specificities [13]. Hence, the decision-support tool compares independently project-based visions – i.e., forward-looking neighborhoods projects – for each site. In that respect, we also present a first test application of the decision-support tool to a case study. The overall objective is to provide stakeholders involved in such projects with specific knowledge to make informed decisions in the early stages of planning and design, not only about sustainability performance but also on the balance between urban and fluvial qualities.

To put the research work into context, the following chapter (Chapter 2) explains the global methodological approach that leads to the realization of the decision-support tool. Then, Chapter 3 explains in detail the structure and functioning of the decision-support tool while focusing on the city-river balance indicators as an original part of the research. Chapter 4 is a test application of the decision-support tool to a case study, namely a 5-hectare sector in Geneva, Switzerland. Finally, Chapter 5 discusses the preliminary results of the test application. Essentially, it reveals the potential of the decision-support tool and underlines the obstacle to overcome before an operational transfer into practice.

Research approach (method)

Fig. 1 schematizes the global *Rhodanie urbaine* research approach taken to develop and test the decision-support tool. At the core of the research project, the tool is structured in two sets of indicators – sustainability indicators and city-river balance indicators – determined according to a combination of distinct yet interconnected methodologies. As shown in Fig. 1, they feed, in an iterative way, the development of the indicators and contribute to structuring and testing the decision-support tool.

Sustainability indicators

The first set of indicators provides a sustainability profile. The holistic dimension of sustainability makes it essential to use transparent, robust, yet accessible and standard indicators. As explained in section 1.2, multi-criteria methods evaluating sustainability performance are manifold, and many are already operational. For this reason, the research retrieves the sustainability indicators from an existing tool. We base our choice on an extensive analysis of existing tools at the neighborhood scale and previous research experiences [41]. This in-depth investigation led to the tool NEBIUS (Neighborhood-scale Evaluation to Benchmark the Integration of Urban Sustainability) [39]. Developed as part of the teaching and research activities of the Laboratory of architecture and sustainable technologies (LAST) at EPFL, it facilitates the evaluation of environmental, socio-cultural, and economic aspects at the neighborhood scale. It aims to optimize and compare urban and architectural visions with simplicity from the earliest design phases of the project. NEBIUS has already been used on several study sites [42–45]. Providing minor adjustments, indicators from NEBIUS appear to be suitable to evaluate key sustainability performances in the case of project-based visions for rhodanian neighborhoods.

City-river balance indicators

Inspired by the concept of Nature-Based Solutions [46,47] and organized under specific thematic components, the second set of indicators provides an overview of the city-river balance potential for project-based visions. City-river balance is a concept that embodied a renewed and serene relationship between urban regeneration – the city space – and renaturation – the river space – within new resilient

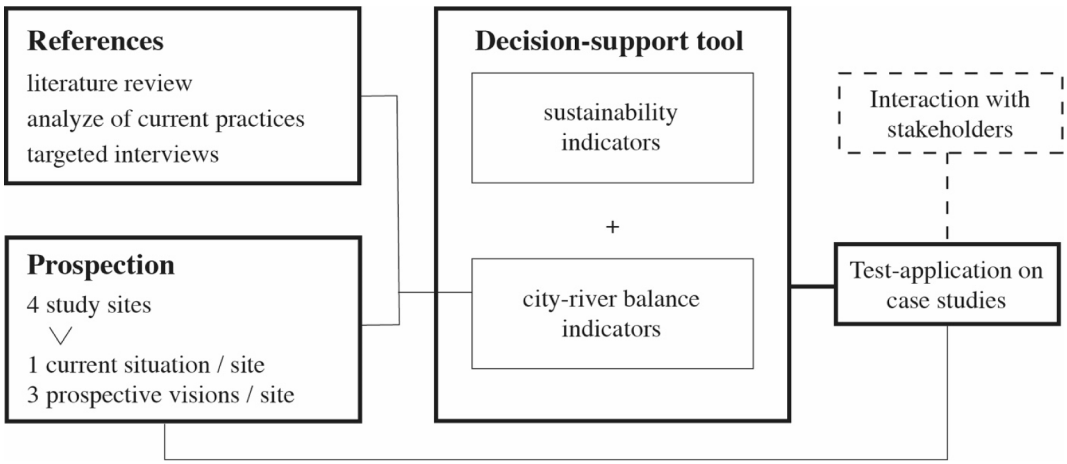


Fig. 1. Schematic representation of the Rhodanie urbaine research approach.

neighborhoods. By nature, components of city-river balance are multi-dimensional and multiscale. The determination of these components, and by extension the indicators, involves two distinct methodological steps: one based on references and one on prospection.

References

The references step includes several multidisciplinary inputs:

- Literature review: an in-depth study of the rhodanian territory under development to increase its understanding and identify its historical, geographical, sociological, cultural, economic, governing, and environmental specificities, characteristics and issues, notably those related to the sustainability transitions and resilience;
- Analyses of current practices: the critical analyses of contemporary urban dynamics along rivers such as new neighborhoods operation or urban landscaping development across Europe;
- Targeted interviews: the solicitation of stakeholders active in urban river territories and coming from a variety of professional backgrounds (architects, urban planners, hydrologists, engineers, geographers, sociologists, politicians, economists, representatives of the study sites, etc.).

Prospection

The prospection step takes a research-by-design approach [40,48], where the project process becomes a concrete research tool that lies between theoretical and operational issues. Research-by-design explores unprecedented links between the methodological rigor of research and

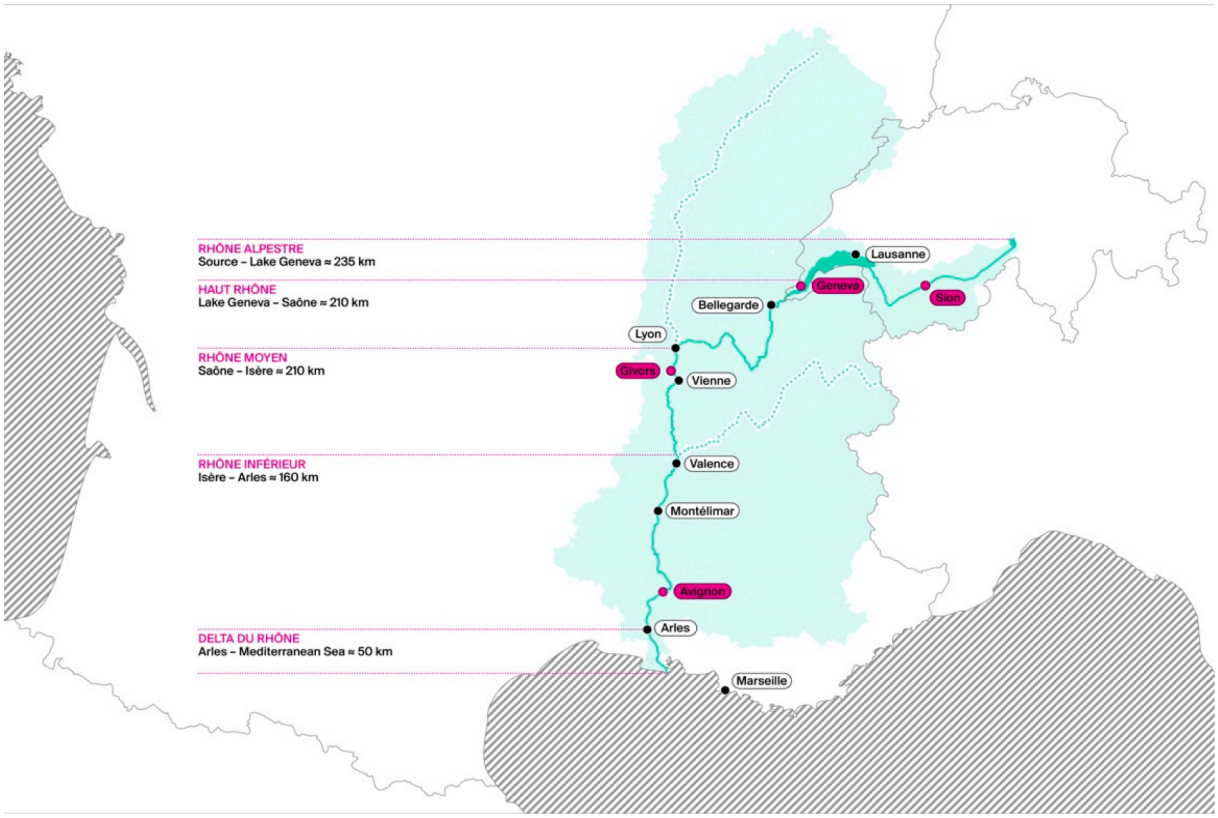


Fig. 2. Study sites and hydraulic regimes of the Rhone.

the inventiveness potential of the project, thanks to the notion of integrated design [49]. The approach can is argued to benefit creative balanced water management in spatial planning [50].

The research project develops, thus, forward-looking visions on study sites along the Rhone, which have the potential for evolution in terms of a new city-river balance. Following the previous literature review, we identify-four (4) study sites, one per hydraulic entity (excluding Delta): Sion located along the *Rhône Alpin*, Geneva along the *Haut Rhône*, Givors along the *Rhône Moyen*, and Avignon along the *Rhône Inférieur* (see Fig. 2). On each study site, three (3) project variants are developed in addition to the current state, for a total of twelve (12) visions. These project-based visions look at the interactions between the urban space and the river space: the buildings' establishment (position to the river, distance to the urban center); the physical environment (size of the site, density, urban morphology, building typologies); usage (type and rate of activity, number of users, cultural elements); the city-river interaction (type and nature of the relationship with the river, public and green spaces, ecosystems, risks). The intention is to see the emergence of possible fluvial features that go beyond a renewed physical contact with the water [40]. In that sense, the project-based visions are the data used for the development as well as the testing of the city-river balance indicators, and more generally, the decision-support tool.

Structure of the decision-support tool

As already mentioned, the decision-support tool includes two sets of indicators (see Fig. 3) – sustainability and city-river balance indicators – which ultimately show the project-based visions' potential strengths and weaknesses.

The structure of the sustainability indicators is based on an existing multi-criteria evaluation method, NEBIUS. To give an overview, it evaluates ten (10) indicators organized under five (5) fundamental

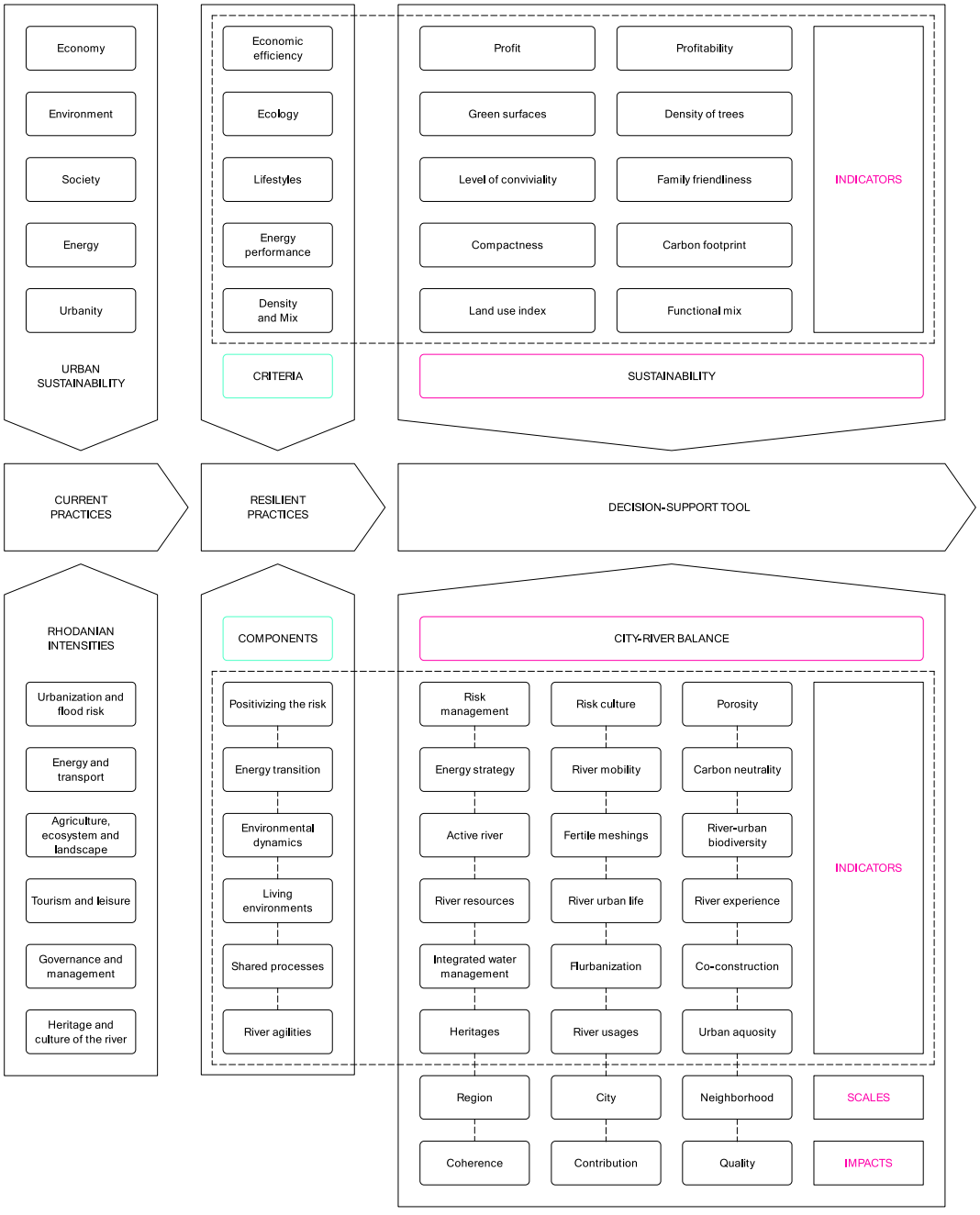


Fig. 3. Rhodanie urbaine Decision-support tool.

criteria: Economic efficiency (Profit, Profitability); Ecology (Green surfaces, Density of trees); Lifestyles: (Conviviality, Family friendliness); Energy performance (Compactness, Carbon footprint); Density and Mix (Land use index, Functional mix). Results are shown in a radar chart, providing each vision with a sustainability profile at the neighborhood scale. Several publications already discuss the NEBIUS method, performance, utility, and limitation [26,29–32].

As original material, we focus here on the development of the elements linked to the evaluation of the city-river balance. Indeed, this part of the decision-support tool is tailored to issues raised by rhodanian neighborhoods in transition. First, we determine a list of city-river balance components that characterize the relationship between the city and the river as well as the issues related to its evolution, namely its transition. Then, we define indicators evaluating each city-river balance component according to a specific spatial scale. Finally, we develop the measurement approach and the visual expression of the results.

Components: From current practices to resilient neighborhoods

At the neighborhood scale, the concept of a new balance between the city and river implies a transition from current practices to the design of resilient neighborhoods. We specify the various components constituting the city-river relationship through the referential and prospective methodologies conducted as part of the research approach.

The initial step is to understand the Rhone territory as a set of resources and fragilities linked to the river and current practices. These "rhodanian intensities" are broken down into six (6) points: Urbanization and flood risk; Energy and transport; Agriculture, ecosystem, and landscape; Tourism, leisure, and recreation; Governance and management; Heritage and river culture. Then follow the components, which define a new city-river balance, understood as resilient urban attitudes in a transition perspective: Positivizing the risk; Energy transition; Environmental dynamics; Living environments; Shared processes; River Agilities.

Indicators: regional, city, and neighborhood scales

On that basis, we define indicators in order to evaluate the degree of satisfaction regarding each component. We give a particular importance to qualitative indicators, provided that it presents explicit information on the vision evaluated. Although quantitative evaluation appears simpler to perform, it is argued that qualitative evaluation has the advantage of certain flexibility and sensitiveness, particularly in a prospective context [51,52]. Moreover, we define and select the indicators respecting six fundamental principles: exhaustiveness, relevance, sensitivity, objectivity, accessibility, readability [53].

Hence, the selected indicators represent the multidimensional issues characterizing river neighborhoods in transition for each city-river balance component. In this perspective, we define three (3) categories of scale: the indicators relating to the region (referring to the coherence of the vision with the territorial aspects of the region); the indicators relating to the city (referring to the contribution of the vision to urban aspects of the city); and the indicators relating to the neighborhood (referring to the quality brought by the vision within the specific perimeter of the site). In total, eighteen (18) indicators are proposed. They aim to compare, for a given site, the city-river balance potential of project-based visions.

Measurement and representation of the results

To measure each city-river balance indicator, we take a two-step evaluation approach. First, we define a question to inquiry for a given indicator to which level the project-based vision has an impact – in terms of coherence, contribution or quality – according to the scale of the indicator – the region, city or neighborhood, respectively (see Fig. 3 and datasheets). The possible answers are yes, partially or no. Then, for the same indicator, we define a balance gradient to evaluate to what extend the project-based vision favor urban or river features or a combination of the two. Five (5) gradients are attributed, going from Highly Urban (UU), Urban (U), Balanced (UF), Fluvial (F), Highly Fluvial (FF). In other words, the gradients lie widely between the "built environment" (UU) and the "fluvial environment" (FF). The level of impact and the balance gradient allow bringing the evaluation results of each indicator at a comparable level of performance. Each of the 18 indicators has its own datasheet containing all the relevant information to perform the evaluation.

As examples, we show below the datasheets of indicators under the first city-river balance component: Positivizing the risk. This city-river balance component consists of an approach allowing a global and positive awareness of the risk transforming the constraint into a project for resilient management methods [54]; thus, the spatial organization brings a specific landscape, a new quality for the sites developed [38]. Table 1, 2, and 3 show the datasheet of a region scale indicator (1a Risk Management), a city scale indicator (1b Risk culture), and a neighborhood scale indicator (1c Porosity), respectively.

How the evaluation results are reported – that is to say, their graphical representation –can have a significant influence on their usefulness in decision-making, the latter being the central objective of this research project. The graphical representation of the results must be simple, clear, and in enough detail to allow some form of transparency [16]. Based on these considerations, we report the evaluation results in a diagram that is designed to communicate the city-river balance of a vision in a synoptic way. The city-river diagram gathers the eighteen indicators under the six city-river balance components and shows simultaneously the different scales (region, city, and neighborhood). For each indicator, a circle represents the impact level (filled, half-filled or empty), which in turn serves as a cursor for the balance gradient, from Higly Urban (UU) to the left to Highly Fluvial (FF) to the right.

Table 1
Datasheet of a region scale indicator (1a Risk Management).

Indicator	**1a Risk Management**
Component	Positivizing the risk
Scale	Region
Type of impact	Regional coherence
Guidance	"Taking a step back, we can thus see urban resilience as being a matter of urban design. But it should not be limited to this. Indeed, it also stands as a matter of territorial planning on scales larger than that of the neighborhood. The resilient organization of a territory should be thought out at a regional or an urban level. At the same time, crisis management should be central and its integration into the development process anticipated every time new urban developments are to be implemented in flood-prone areas." [55]
Question	Is the project-based vision coherent with regional flood risk management strategies?
Level of impact	Yes, the vision is coherent Partially, the vision is coherent to some extent No, the vision is not coherent
Guidance	"Through intense study, particularly of the processes that occur in bodies of water, we came to the conclusion that the determination of the river's limits, the way in which those limits are set, is the decisive factor." [56]
Definition	Types of limitations of the flood zone and the channel
Balance gradient	UU = Overlapping limitations of the flood zone and the channel U = Occasional dissociation of the flood zone limitation and channel limitation UF = Systematic dissociation of the flood zone limitation and channel limitation F = Flood zone limitation only FF = No limitation to the river dynamics
Data	Current state and project-based visions
References / tools	> Sion: PA-*R*3 [12], SDANA [57] > Genève: SPAGE [58], SITG [59] > Givors: PGRI [60,61], TRI [62] > Avignon: PGRI [60,61], TRI [63]

Table 2
Datasheet of a city scale indicator (1b Risk culture).

Indicator	1b Risk Culture
Component	Positivizing the risk
Scale	City
Type of impact	Contribution to the city
Guidance	" If living on the banks of a river means running the risk of being flooded one day, then the social sciences teach us that it is not only necessary to predict and anticipate it, but also to say it and to transmit it. This passes, we measure it today, less by communication plans than by renewed forms of socialization of the river." [64] *(Quote translated by the authors)*
Question	Does the project-based vision contribute to the perpetuation of a risk culture among the inhabitants and users of the public spaces (Raising awareness and informing the inhabitants about their exposure, Maintaining the installations in time, Training the civil servants about the risk)?
Level of impact	Yes, the vision contributes Partially, the vision contributes to some extent No, the vision does not contribute
Guidance	" These strategic axes are complementary: the places where one resists, those where one accepts the hazard by improving resilience, those from which one withdraws or that one sanctuaries are defined according to an overall, multiscalar vision." [38] *(Quote translated by the authors)*
Definition	Type of strategy to tackle the hazard (resistance, resilience, retreat) and connection of the built morphology to the river
Balance gradient	UU = Resistance (dike) and built morphology disconnected from the river U = Resistance (dike) and built morphology in relation with the river UF = Resilience, floodable public space F = Resilience, floodable building FF = Retreat of the urbanization or *sanctuarization*
Data	Current state and project-based visions
References / tools	Suisse: PA-*R*3 [12] France: Plan Rhône [38,64]

Table 3
Datasheet of a neighborhood scale indicator (1c Porosity).

Indicator	1c Porosity
Component	Positivizing the risk
Scale	Neighborhood
Type of impact	Quality of the neighborhood
Guidance	" This porosity must be considered at every territorial scale. At the watershed level, spaces must be set aside to store large volumes of water, following the model of the "Room for the River" policy in the Netherlands. It is also a matter of reserving sufficient space for water flow between blocks of buildings in the context of new urban developments. Finally, infiltration and water retention systems should be required in all public spaces and buildings." [65] *(Quote translated by the authors)*
Question	Does the project-based qualify spaces for water flow between buildings (urban morphology) as well as infiltration surfaces and water retention devices (soil and roofs)?
Level of impact	Yes, the vision qualifies a porosity Partially, the vision qualifies a porosity to some extent No, the vision does not qualify a porosity
Guidance	" One promising measure for adapting to climate change is to transform urban areas into "sponge cities". These absorb rainwater like a sponge and thus help to minimize the damage resulting from torrential rains. In addition, sponge cities improve the urban climate during heat waves by providing shade from locally adapted trees. These trees, in conjunction with vegetated facades and roofs, evaporate enough water to provide effective natural cooling. This effectively reduces the "heat island" effect that can lead to a temperature difference of more than 10 °C between the city and its surroundings. At the same time, the open water and vegetation surfaces encourage biodiversity." [66]
Definition	Percentage of permeable surfaces compared to the total land area (green roofs accounted for 50%)
Balance gradient	UU = Infiltration surface less than or equal to 24% U = Infiltration area between 25% and 49% UF = Infiltration surface between 50% and 64% F = Infiltration area between 65% and 74% FF = Infiltration surface greater than or equal to 75%
Data	Current state and project-based visions
References / tools	[65,66]

Ultimately, for a given rhodanian site, the evaluation provides a city-river balance diagram for each vision developed as well as the current state. When adding these results to the sustainability profile, straightforward comparisons can be made.

Test application to a study site

We now have a decision-support tool in hand, which intention is to compare not only the sustainability performances of project-based visions but mainly their city-river balance potentialities. An essential step in its development is to perform test applications to different study sites. In a first instance, the goal is to verify the robustness and functioning of the decision-support tool, looking principally at the evaluation features of the city-river balance indicators and the clarity of the results. This process contributes to the iterative optimization of the indicators previously developed and refinement of the graphic representation of the evaluation results. It also aims to improve its transfer potential into practice.

Here, we present the preliminary results of one of the four study sites: the *Jonction* neighborhood in Geneva (CH) located along the *Haut Rhône*. To better understand the evaluation results, we describe below the current state of the study site and the three project variants that were developed. Then we explain the detailed results of three indicators of the city-river balance component "Positivizing the risk" and show the global evaluation results.

Description of the study site

In the heart of the city center of Geneva and characterized by an industrial and tenuous urban fabric, the *Jonction* neighborhood presents a strong potential for regeneration. A unique place in the Geneva conurbation, at the confluence of the Rhone and Arve rivers, this neighborhood is indeed a particularly strategic space for creating new links between the city and its river. The 5-hectare site is home to a depot of the *Geneva Public Transport* (TPG), whose location will be reconsidered in the coming decades. Part of this new dynamics, the *Pointe de la Jonction* park project at the tip of the site is currently under development. Fig. 4 is an aerial view of the study site, which highlights the western limit of the city's dense urbanization. The site benefits from a remarkable landscape richness, framed by the cliffs of *St-Jean* on the north side and by the *Bois de la Bâtie* on the south side. Close to a major public transportation hub, the site is bounded by two residential blocks to the east and a railway viaduct to the west, while two roadways serve the area. The left bank of the Rhone has a promenade and a wooden platform for swimming and relaxation. A place of meeting and animation in summer, several aquatic activities take place there, and a refreshment bar is available to the public. Some cultural activities are present in the former Kugler factory.

Description of the project-based visions

We adopt three prospective attitudes to design the project-based visions, that constitute the data: Weave, Orient, and Deploy. They concern the specific contribution of the new neighborhood to the nature of the spatial relationships between the urban fabric of the existing city and the landscape area of the river.

- Weave: The prospective attitude weaves sequenced links with the river's landscape space. It translates into an urban form and urban

Fig. 4. Aerial view of the Rhone in Geneva: at the junction between the Rhone and the Arve, and held by the cliffs of St-Jean to the north and the Bois de la Bâtie to the south. [photo © Nicolas Sedlatchek].

structure that are part of an extension logic of the existing built fabric of the city.
- Orient: The prospective attitude orients and opens up the existing built fabric of the city towards the river. It translates into an urban form that alternates between concentrated built spaces and unbuilt public spaces.
- Deploy: The prospective attitude deploys a river frontage that is permeable to the existing built fabric of the city. It translates into a large-scale urban form that enters in dialogue with the larger landscape while offering a vast public space at the water's edge.

With this in mind, the visions explore the multiple issues and potentialities for the evolution of the study area and its specific characteristics (see Fig. 5). It involves relevant reflections about the public spaces and the interaction with the cultural activities already present in the former Kugler factory. The creation of new studios is notably proposed. We name the current state GE0 and the three project-based visions GE1 (Weave), GE2 (Orient), and GE3 (Deploy).

Project-based vision GE1 (Weave)

The vision continues and completes the built fabric of the city center by reinterpreting it. It first proposes two courtyard blocks, one closed and one open, while the existing large block to the south is expanded. An annex building on the east side of the rehabilitated Kugler factory accommodates all the studios. The first floors are dedicated to businesses and shops, while the upper levels are used for housing. Generous landscaped banks enhance the two rivers, and a new footbridge crosses the Rhone. This vision creates a stretched place between the two rivers, which constitutes a filter towards the *Pointe de la Jonction* park while connecting the housing and cultural pole.

Project-based vision GE2 (Orient)

The vision presents a morphology composed of five built entities in a public park. Three towers are each positioned in a particular relationship with the context: the north tower borders the Rhone, the west tower highlights the junction between the two rivers, and the south tower ends the existing urban fabric. A long studio building facing the park and a housing block complete the vision, while the historic TPG building is rehabilitated as a community center. The three towers offer, with their first and last floors open to the public, privileged openings on the larger landscape. The *Pointe de la Jonction* park extends over the entire perimeter and enhances the banks of the rivers. A new footbridge crosses the Rhone. This vision creates a new inhabited landscape.

Project-based vision GE3 (Deploy)

The vision presents a single building located in the northern part of the site, held between the Kugler factory to the west – which contains the studios – and the existing residential block to the east. In the southern part, a wide area of collective vegetable gardens enhances the Arve's river bank. The large, permeable block houses three planted courtyards for the residents. Most of the first floor is dedicated to commercial activities, while the upper levels are for housing. A circuit is articulated throughout the block, linking the courtyards to the collective space of the roof via exterior walkways and interior corridors. A broad urban bank on its left becomes the main public river space of the project. In a unitary urban gesture, this vision renews the relationship with the Rhone.

Detailed and global results

The evaluation of the current state (GE0) and three visions (GE1, GE2, GE3) is performed by the research team. In order to explain the logic of the two-step evaluation process, we detail below the results for the city-river balance component "Positivizing the risk" at the three different spatial scales indicators. Then we show the global city-river balance results in the diagram, which will allow comparing the different visions.

Region - risk management

For this indicator, the scale of the Canton of Geneva is taken. The flood risk management is based on the hazard map [59], which shows a

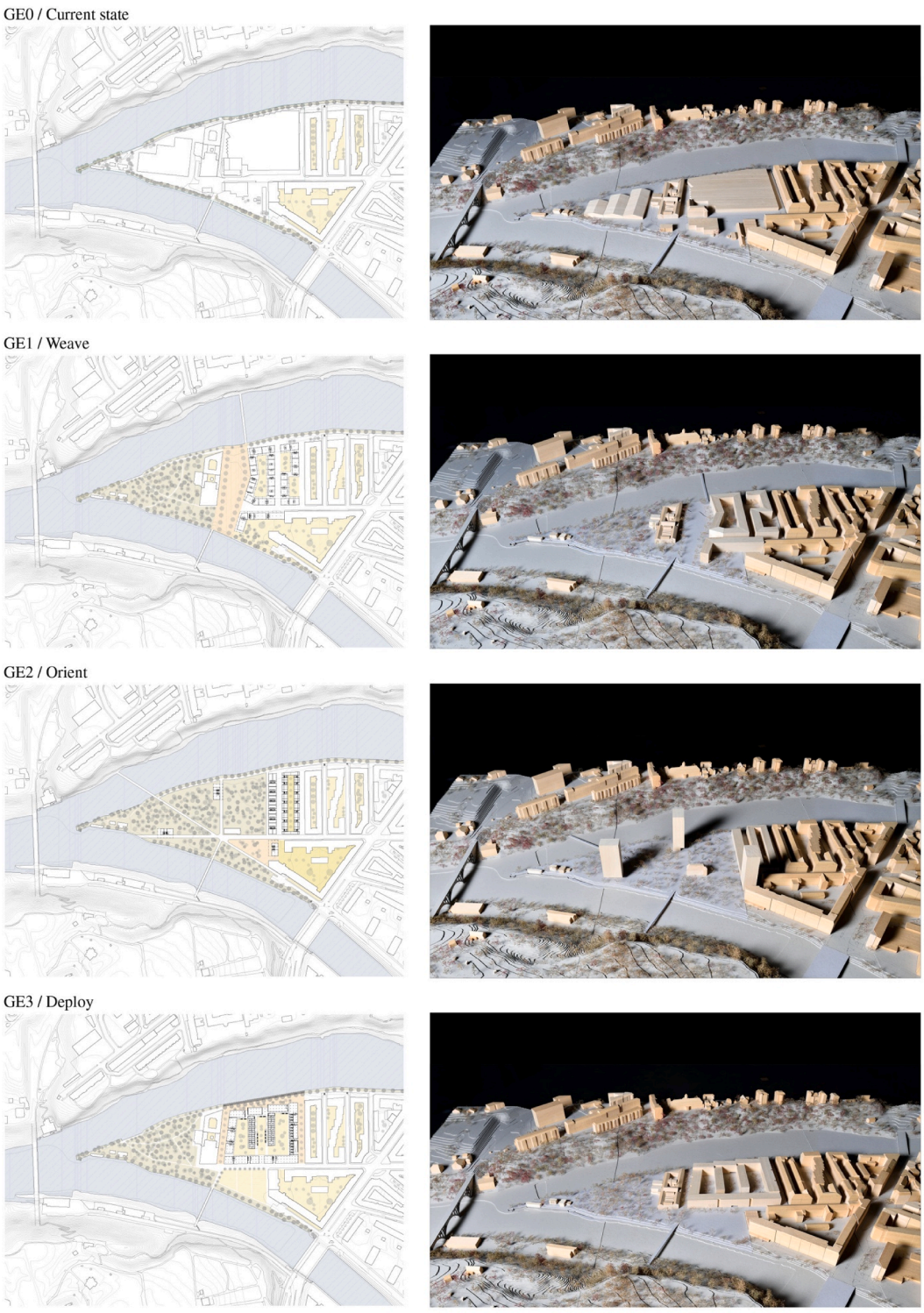


Fig. 5. Ground floor plans and models. [photos © Olivier Wavre].

medium level flood risk on the western end of *Pointe de la Jonction*. This area cannot be really urbanized, and is therefore destined to become a public urban park [58], the project of which is currently being developed [67].

Step 1 (question): As the cantonal framework conditions are respected both by the current state (GE0) and by the project-based visions GE1, GE2 and GE3, coherence on a regional scale is always confirmed (answer Yes).

Step 2 (gradients): Regarding the city-river balance, on the other hand, these same protection requirements related to flood risks define a Highly Urban gradient (UU). Indeed, in all the project-based visions, the limitations of the flood zone and the channel are superimposed, except for GE3 (Urban gradient, U) which proposes a punctual dissociation of these limitations in the form of flood steps (see Table 1).

City - risk culture

The development of risk culture is an indispensable tool in the path

towards city resilience [68] and can take multiple forms: videos [69], awareness-raising campaigns [70], mediation and scientific contextualization [71], access to water [72], etc. For this indicator, the scale of the city of Geneva is taken.

Step 1 (question): Apart from the current state which only does this in part (answer Partially), all the visions contribute to the perpetuation of the risk culture on a city-wide scale. The banks of the Rhone between the *Pont Sous-Terre* and the *Pointe de la Jonction* are dedicated to swimming, and users are informed of the risks associated with this activity. The project-based visions GE1, GE2 and GE3 consolidate this

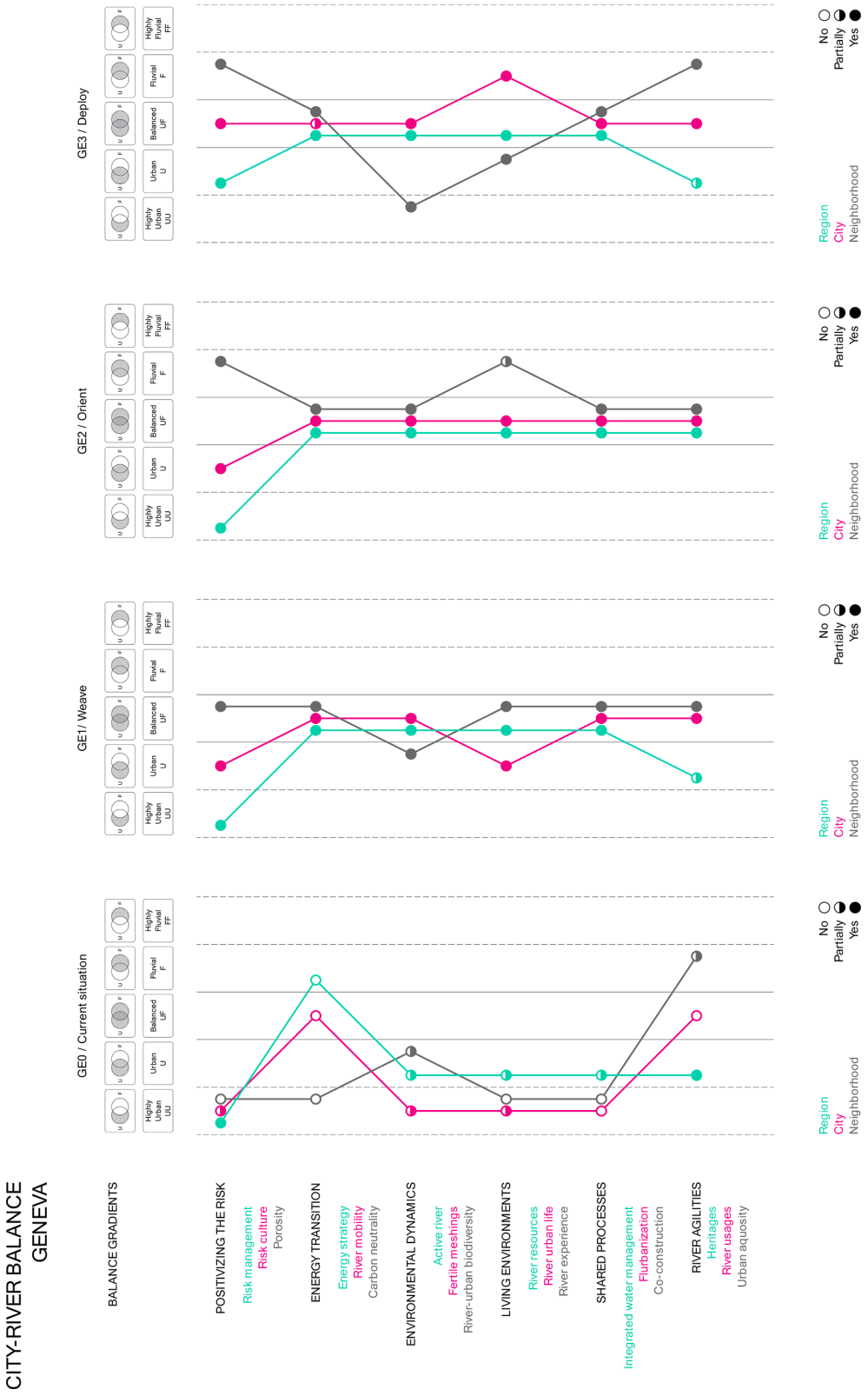


Fig. 6. Results for the Geneva study site.

contribution (answer Yes) by also aiming to raise awareness about the risk of flooding, as well as lasting action in terms of riverbank development.

Step 2 (gradients): The city-river balance varies between the Highly Urban (GE0, UU) and Urban (GE1 and GE2, U) gradients in relation to the type of strategy adopted in the face of the hazard; whereas GE3 shows a Balanced gradient (UF) thanks to its public space subject to flooding, which encourages risk culture by making water changes explicit (see Table 2).

Neighborhood - porosity

For this indicator, the scale of the *Jonction* neighborhood is taken. The "Porosity" indicator focuses on the flow, infiltration and retention of water within the neighborhood. Indeed, both the urban form and the treatment of the soil have an impact on these parameters [65]. According to the Swiss Association of Water Protection Professionals (VSA) guidelines and the Sponge City concept [66,73], the main strategy is to maximize infiltration to decrease the need for retention.

Step 1 (question): The current state (GE0), due to its priority road use in connection with the *Geneva Public Transport* (TPG) services, is very impermeable and therefore does not qualify any kind of porosity at the neighborhood scale (answer No). The three project-based visions (GE1, GE2, GE3) on the contrary all meet this objective (answer Yes).

Step 2 (gradients): The portion of permeable surfaces in the GE1 project-based vision corresponds to a Balanced gradient (UF), while GE2 and GE3 rather define a Fluvial gradient (F, more than 65% of infiltration surface), giving particularly favorable space to water (see Table 3).

City-river balance global results

Overall, the results for the Geneva study site shown in Fig. 6 indicate a clear evolution between the current state (GE0) and the different project-based visions (GE1, GE2 and GE3).

For the current state (GE0), the answers to the questions of the first step of the evaluation correspond for the most part to No or Partially. This diagnosis confirms the need to deepen the levels of the impacts (Regional coherence, Contribution to the city, Quality of the neighborhood), in order to reach Yes answers. In this sense, the three project-based visions (GE1, GE2, GE3) answer Yes to nearly all the questions (only one Partially per vision), the first guarantee of a renewed city-river relationship.

In the second step of the evaluation, we note the propensity of the current state (GE0) towards Highly Urban (UU) or Urban (U) balance gradients, while the three project-based visions show a tendency towards balance (UF), particularly GE2.

Discussion

Although the test application cannot be an absolute and definitive confirmation of the tool's efficiency, it underlines its potential to raise awareness and facilitate the integration of a new city-river balance within neighborhoods in transition. We discuss here the results from this angle.

First, the test application allows us to make a certain number of observations regarding the functioning of the decision-support tool. We successfully assessed the eighteen indicators with the data retrieved from the project-based vision. We should note that measurement of most of the indicators were optimized during the process. This iterative process between the development of the project-based visions and the fine-tuning of the city-river balance indicators is part of the research-by-design approach. In general, we found that an accurate study site analysis and the flexibility of the tool allow to take into account the typomorphological, economic and political particularities. The results allow to compare the different city-river balance potentialities and issues by vision.

If we only look at the project-based visions (GE1, GE2, GE3), some trends can be read in relation to the three categories of scale.

- The indicators at the regional scale are mostly Balanced (UF), except two of them, which tend to an Higly Urban (GE1 and GE2, UU) or an Urban (GE3, U) gradient. For "Risk management" it is due to the usual flood protection strategy in cities, which focuses on extreme vulnerability reduction. For "Heritages", the Balanced gradient (UF) wishes to promote the cultural heritage of the river through a *Maison du Rhône*, which is supported only by the project-based vision GE2. Moreover, GE1 and GE3 do not propose the patrimonial valorization of the existing protected building on the site.
- The indicators at the city scale are also mostly Balanced (UF), again except two of them. For "Risk management", the Urban gradient (GE1 and GE2, U) is related to the lack of sufficiently large and lasting developments along the riverbanks. "River urban life" is the indicator that shows the most variable balance gradient, confirming that the city development and its relationship to the river has significant influence on lifestyles.
- The indicators at the neighborhood scale fluctuate the most on both sides of the Balanced gradient (UF), especially in the evaluation of the project-based vision GE3. The relevance of the neighborhood scale as an activator (or a brake) of the city-river balance then seems to be confirmed.

By indicators, there is often a link between the balance gradients of the different scales. This is due to the coherence that is naturally established between one scale and the other. However, we note that the indicator "Positivizing the Risk" differ more strongly, as risk management in cities - at least on a regional scale - tends to be more defensive than resilient. The indicator "Living Environments" also shows a slight movement of the balance gradient through the project-based visions. Apart from the regional scale which is Balanced (UF) in all three cases, the other two vary between Fluvial (F) and Urban (U). This highlights the influence of urban form and architectural quality in fluvial neighborhoods, as operational levers towards a city-river balance.

Ultimately, the test application confirms the relevancy of the city-river balance components. Together, they have the potential to reveal and support the design of resilient visions for rhodanian neighborhoods in transition.

Because this test application is a verification process performed within a research project framework, the idea is not to give formal recommendation. That said, we can affirm that the project-based visions propose generally much more Balanced gradients. However, it is not possible to make an average calculation between certain urban (UU, U) and fluvial (F, FF) gradients to assess the notion of city-river balance. It is rather a set of indicators that, at different scales and according to different components, each assess the degree of balance. In this sense, the project-based vision GE2 has the highest potential to reach a city-river balance, with a slight fluvial trend. It is followed by GE1, which on the other hand shows an urban trend, while GE3 is the least balanced, its gradient varying between Fluvial (F) and Highly Urban (UU). As no project-based vision reaches a perfect balance, this approach allows to question the priorities of each study site by adjusting the specific objectives that arise, consciously and explicitly.

This decision-support tool does not offer ready-made solutions. It is rather expected to help clarifying the needs and expectations of different stakeholders, understand the specific characteristics, strengths and weaknesses of concerned sites, and develop adapted projects. In that sense, it must contribute to the decision but not replace it. This is where the tailor-made tool is interesting by bringing detailed information on specific city-water dimensions in order to facilitate trade-offs and help decision-making in the perspective of the global quality of new resilient neighborhoods. The test application results are in line with these considerations and show, in that sense, the potential added-value to current practice of the decision-support tool.

Finally, more feedback on the usability of the decision-support tool in different professional contexts could contribute to corroborating the results of the test application and improving its usability. Interactions with stakeholders in the field will be part of the next steps of the research work. A next experimentation could also be its integration in the early-stage formulation of a real-world project.

Conclusion

City-river relationships are evolving, multidimensional, and emblematic of the urban issues related to the ecological transition. In order to contribute to the development of resilient fluvial neighborhoods, the concept of a new city-river balance is developed, focusing on the Rhone territory. It involves a transition from current practices to resilient practices. The concept is embedded in a tailor-made decision-support tool made of sets of indicators: sustainability profiles and city-river balance indicators. The sustainability indicators are based on the NEBIUS methodology, which facilitates the evaluation of key aspects of sustainability. The city-river balance indicators are structured around six components, each one declined in three dimensions referring to spatial scales. This tool of mostly qualitative indicators offers a multi-criteria comparison of the sustainability and city-river balance's potential of project-based visions in order to promote resilient and sustainable neighborhoods. Its functioning is explained through a test application on a study site located in Geneva. The results contribute to verifying the optimization and verification of the indicators and their graphical representation. Moreover, it shows the decision-support tool transfer potential into practice.

Beyond the development of theoretical knowledge on the concept of city-river balance, the current research provides a specific decision-support tool for the benefit of the decision-makers involved in the transition of neighborhoods along the Rhone. It could foster collaboration amongst experts coming from various professional backgrounds to guarantee a multidisciplinary approach, which is essential to the integration of sustainability and resilience issues. In that sense, the tool could contribute to the decision-making in a multidisciplinary manner, without ever giving ready-made solutions, but allowing iterative improvements of the project; it offers not only an unprecedent manner to assess and compare projects but also guidance to elaborate resilient project-based visions that highlight rhodanian features and better inscribe a city-river balance as a common long-term goal. It could further be adapted to other rivers' contexts. The next step of the *Rhodanie urbaine* research project includes the test application of the tool to the three other study sites, the confrontation of the results to a panel of practitioners related to the four study sites and, finally, the application of the decision-support tool on a real-world project.

CRediT authorship contribution statement

Sara Formery: Conceptualization, Methodology, Investigation, Visualization, Writing – review & editing. **Martine Laprise:** Conceptualization, Validation, Writing – original draft. **Emmanuel Rey:** Conceptualization, Validation, Supervision, Project administration.

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.

Acknowledgments

The authors warmly thank the architecture students who participated in the *Rhodanie urbaine* studios, as well as all the stakeholders involved in the targeted interviews, for their contributions to the research project.

References

[1] Lensel B, Morandeau V. L'eau et la ville. Je t'aime moi non plus., Techni.Cités. (2014).
[2] Chasseriau A, Peyon J-P. Le projet Ile de Nantes, ou comment la ville se réconcilie avec son fleuve. ESO Travaux et documents 2004;22:41–50.
[3] Chaline C. La reconversion des espaces fluvio-portuaires dans les grandes métropoles. Annales de géographie 1988;97:695–715. https://doi.org/10.3406/geo.1988.20718.
[4] Lechner G, Le fleuve dans la ville. La valorisation des berges en milieu urbain., Direction générale de l'urbanisme de l'habitat et de la construction, Paris, 2006.
[5] White KN. Urban waterside regeneration: problems and prospects. New York [etc: Ellis Horwood; 1993.
[6] Formery S, Laprise M, Rey E. Quartiers rhodaniens en transition, Cahier spécial de TRACES. (2022):13–15.
[7] Mahaut V. L'eau et la ville, le temps de la réconciliation : jardins d'orage et nouvelles rivières urbaines. UCL: Text; 2009. http://dial.academielouvain.be/handle/boreal:27832 (accessed September 24, 2013.
[8] Bonnet F. Vivre avec le fleuve, l'exemple de Nantes, (2021).
[9] Heinzlef C, Robert B, Hémond Y, Serre D. Operating urban resilience strategies to face climate change and associated risks: some advances from theory to application in Canada and France. Cities 2020;104:102762. https://doi.org/10.1016/j.cities.2020.102762.
[10] Bonin S. Fleuves en ville : enjeux écologiques et projets urbains. Matériaux pour la recherche en sciences sociales: Strates; 2007. http://journals.openedition.org/strates/5963 (accessed June 15, 2018.
[11] CPIER, CPIER - Plan Rhône 2015-2020 Contrat de Plan Interrégional Etat Régions 2015-2020, 2015.
[12] du Valais C. Troisième correction du Rhône. Sécurité pour le futur. Rapport de Synthèse; 2016. Plan d'aménagement (PA-R3).
[13] Formery S, Laprise M, Rey E. Integrative decision-making strategy for fluvial neighborhoods in transition. IOP Conf Ser: Earth Environ Sci 2020;588:042005. https://doi.org/10.1088/1755-1315/588/4/042005.
[14] Pediaditi K, Doick KJ, Moffat AJ. Monitoring and evaluation practice for brownfield, regeneration to greenspace initiatives: A meta-evaluation of assessment and monitoring tools. Landsc Urban Plan 2010;97:22–36. https://doi.org/10.1016/j.landurbplan.2010.04.007.
[15] UNCED, Report of the United Nations conference on environment and development, Rio de Janeiro, 1992. http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm.
[16] Rey E, Laprise M, Lufkin S. Sustainability Monitoring: Principles, Challenges, and Approaches. In: Rey E, Laprise M, Lufkin S, editors. Neighbourhoods in Transition: Brownfield Regeneration in European Metropolitan Areas. Cham: Springer International Publishing; 2022. p. 121–42. https://doi.org/10.1007/978-3-030-82208-8_8.
[17] Klopp JM, Petretta DL. The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. Cities 2017;63:92–7. https://doi.org/10.1016/j.cities.2016.12.019.
[18] eurostat, SDG 11 - Sustainable cities and communities - Statistics Explained, Eurostat Statistics Explained. (2019). https://ec.europa.eu/eurostat/statistics-explained/index.php?title=SDG_11_-_Sustainable_cities_and_communities&oldid=439596 (accessed June 2, 2020).
[19] Sharifi A, Dawodu A, Cheshmehzangi A. Neighborhood Sustainability Assessment Tools: A Review of Success Factors. J Clean Prod 2021:125912. https://doi.org/10.1016/j.jclepro.2021.125912.
[20] Adewumi AS. Enhancing urban regeneration at the neighbourhood level: the role of sustainability assessment frameworks. Emerald Open Res 2020;2:1. https://doi.org/10.35241/emeraldopenres.13418.2.
[21] Bell S, Morse S. Measuring sustainability : learning by doing, Reprint 2006, Earthscan Publications, London, 2006. http://books.google.ch/books?hl=fr&lr=&id=6DOC13cd9c0C&oi=fnd&pg=PR5&dq=maximum+number+of+sustainability+indicators&ots=IqzOEURylw&sig=pu-xgfP51DiTFcAfSuLjIVYLrmU#v=onepage&q=maximum%20number%20of%20sustainability%20indicators&f=false.
[22] Sharifi A, Murayama A. Neighborhood sustainability assessment in action: Cross-evaluation of three assessment systems and their cases from the US, the UK, and Japan. Build Environ 2014;72:243–58. https://doi.org/10.1016/j.buildenv.2013.11.006.
[23] Sala S, Ciuffo B, Nijkamp P. A systemic framework for sustainability assessment. Ecol Econ 2015;119:314–25. https://doi.org/10.1016/j.ecolecon.2015.09.015.
[24] Pedro J, Reis A, Duarte Pinheiro M, Silva C. A systematic review of the international assessment systems for urban sustainability. IOP Conf Ser: Earth Environ Sci 2019;323:012076. https://doi.org/10.1088/1755-1315/323/1/012076.

[25] Che Y, Yang K, Chen T, Xu Q. Assessing a riverfront rehabilitation project using the comprehensive index of public accessibility. Ecol Eng 2012;40:80–7. https://doi.org/10.1016/j.ecoleng.2011.12.008.
[26] Moosavi S, Browne GR. Advancing the Adaptive, Participatory and Transdisciplinary decision-making framework: The case of a coastal brownfield transformation. Cities 2021;111:103106. https://doi.org/10.1016/j.cities.2021.103106.
[27] Hermida A, Cabrera-Jara N, Osorio P, Cabrera S. Methodology for the assessment of connectivity and comfort of urban rivers. Cities 2019;95.
[28] Hua J, Chen WY. Prioritizing urban rivers' ecosystem services: An importance-performance analysis. Cities 2019;94:11–23. https://doi.org/10.1016/j.cities.2019.05.014.
[29] Inácio M, Gomes E, Bogdzevič K, Kalinauskas M, Zhao W, Pereira P. Mapping and assessing coastal recreation cultural ecosystem services supply, flow, and demand in Lithuania. J Environ Manage 2022;323:116175. https://doi.org/10.1016/j.jenvman.2022.116175.
[30] Ramos TB. Sustainability Assessment: Exploring the Frontiers and Paradigms of Indicator Approaches, Sustainability. (2019).
[31] Pintér L, Hardi P, Martinuzzi A, Hall J. Bellagio STAMP: Principles for sustainability assessment and measurement. Ecol Ind 2012;17:20–8. https://doi.org/10.1016/j.ecolind.2011.07.001.
[32] Bleicher A, Bartke S. Decision support for sustainable land re-use - international application of approaches and tools, in: 2012.
[33] Sharifi A, Murayama A. A critical review of seven selected neighborhood sustainability assessment tools. Environ Impact Assess Rev 2013;38:73–87. https://doi.org/10.1016/j.eiar.2012.06.006.
[34] John B, Keeler LW, Wiek A, Lang DJ. How much sustainability substance is in urban visions? – An analysis of visioning projects in urban planning, Cities. 48 (n.d.) 86–98.
[35] LAST EPFL, RHODANIE URBAINE, (n.d.). https://rhodanieurbaine.ch/ (accessed October 6, 2021).
[36] Nations Unies, Transformer notre monde: le Programme de développement durable à l'horizon 2030, (2015).
[37] Ribeiro PJG, Pena Jardim Gonçalves LA. Urban resilience: A conceptual framework. Sustain Cities Soc. 2019:50;101625. https://doi.org/10.1016/j.scs.2019.101625.
[38] Bonnet F, Morel J-F, Reuillard J. Atout risques: des territoires exposés se réinventent. Marseille: Éditions Parenthèses; 2016.
[39] Lufkin S, Rey E, editors. Neighbourhood-scale Evaluation to Benchmark the Integration of Urban Sustainability (NEBIUS). An innovative education and research methodology, in: Edinburgh, 2017. https://infoscience.epfl.ch/record/228957.
[40] Formery S, Laprise M, Rey E. Rhodanian Neighborhoods in Transition: Towards an Integrative Strategy Facilitating Decision-Making for New Sustainable Fluvio-Neighborhoods, in: 2022.
[41] Laprise M. Monitoring opérationnel pour l'intégration des enjeux de durabilité aux projets de régénération de friches urbaines., Ecole polytechnique fédérale de Lausanne (EPFL), 2017. https://infoscience.epfl.ch/record/232432.
[42] Rey E, Lufkin S, Andersen M, Nault E, Kaufmann V, Thomas M-P, et al. Green density. Lausanne: Presses Polytechniques et Universitaires Romandes; 2013.
[43] Rey E, Andersen M, Erkman S, Guye A, Laprise M, Lufkin S, et al. Urban recovery. Lausanne: Presses Polytechniques et Universitaires Romandes; 2015.
[44] Rey E, Andersen M, Feddersen P, Frank F, De Herde A. Suburban polarity. Lausanne, Switzerland: Presses Polytechniques Universitaires Romandes; 2017.
[45] Rey E, editor. Living Periphery. Lausanne, Switzerland: Presses Polytechniques Universitaires Romandes; 2022.
[46] Kabisch N, Frantzeskaki N, Hansen R. Principles for urban nature-based solutions. Ambio 2022. https://doi.org/10.1007/s13280-021-01685-w.
[47] UICN, Standard mondial de l'UICN pour les solutions fondées sur la nature, 978th-2nd-8317th-2059th–3rd ed., Gland, Suisse, 2020.
[48] E.A. for A.E. EEAE, EAAE Charter on Architectural Research, (2012). https://www.eaae.be/about/statutes-and-policypapers/eaae-charter-architectural-research/ (accessed September 17, 2021).
[49] Larsson N. Integrated Design Process, (2009).
[50] Solarek K, Pudełko A, Mierzwicki K, Solarek K, Bartosik Z, Pyjor A. The potential of the research by design method in balancing water problems: An integrated water and space management program for a part of the Warsaw agglomeration, Cities. 121 (2022) 103455-. https://doi.org/10.1016/j.cities.2021.103455.
[51] Laprise M, Lufkin S, Rey E. An indicator system for the assessment of sustainability integrated into the project dynamics of regeneration of disused urban areas. Build Environ 2015;86:29–38. https://doi.org/10.1016/j.buildenv.2014.12.002.
[52] Zheng HW, Shen GQ, Wang H. A review of recent studies on sustainable urban renewal. Habitat Int 2014;41:272–9. https://doi.org/10.1016/j.habitatint.2013.08.006.
[53] Rey E. Régénération des friches urbaines et développement durable : vers une évaluation intégrée à la dynamique du projet. Louvain-La-Neuve: Presses Universitaires de Louvain; 2012.
[54] Assouline L. Les fleuves dans le projet urbain : entre risque et identité paysagère, Projets de paysage. Revue scientifique sur la conception et l'aménagement de l'espace 2019. https://doi.org/10.4000/paysage.627.
[55] Rode S, Guevara S, Bonnefond M. Resilience in urban development projects in flood-prone areas: a challenge to urban design professionals. Town Plan Rev 2018;89:167–90. https://doi.org/10.3828/tpr.2018.10.
[56] Prominski M, Stokman A, Stimberg D, Voermanek H, Zeller S. River.Space.Design, Planning Strategies, Methods and Projects for Urban Rivers, Birkhäuser, Berlin, Boston, 2012. https://doi.org/10.1515/9783034611732.
[57] Canton du Valais, Service des dangers naturels SDANA, (n.d.). https://sitonline.vs.ch/dangers/danger_hydrologique/fr/ (accessed April 20, 2022).
[58] Office cantonal de l'eau (OCEau), Eau - SPAGE Lac - Rhône - Arve, (2014). https://www.ge.ch/node/13584 (accessed July 26, 2021).
[59] L. territoire genevois à la carte SITG, Dangers de crues et inondations, (2022). https://ge.ch/sitg/ (accessed July 14, 2022).
[60] DREAL Auvergne-Rhône-Alpes, Plan de gestion des risques d'inondation (PGRI) 2022-2027. Bassin Rhône-Méditerranée. Volume 1, (2022). https://www.rhone-mediterranee.eaufrance.fr/gestion-de-leau/gestion-des-risques-dinondation-pgri/le-plan-de-gestion-des-risques-dinondation-pgri-2016-2021 (accessed July 26, 2021).
[61] DREAL Auvergne-Rhône-Alpes, Plan de gestion des risques d'inondation (PGRI) 2022-2027. Bassin Rhône-Méditerranée. Volume 2, (2022). https://www.rhone-mediterranee.eaufrance.fr/gestion-de-leau/gestion-des-risques-dinondation-pgri/le-plan-de-gestion-des-risques-dinondation-pgri-2016-2021 (accessed July 26, 2021).
[62] DREAL PACA Service PR-IPRN, Directive Inondations Bassin Rhône-Méditerranée. Territoire à Risque Important d'inondation (TRI) de Lyon, 2014.
[63] DREAL PACA Service PR-IPRN, Directive Inondations Bassin Rhône-Méditerranée. Territoire à Risque Important d'inondation (TRI) d'Avignon - Plaine du Tricastin - Basse Vallée de la Durance, 2014.
[64] Vincent A, Tröger K. La mémoire du risque d'inondation: le cas du Rhône français, in: Le Rhône: Dynamique, Histoire et Société, Vallesia, Archives de l'Etat du Valais, Sion, 2009: pp. 197–215.
[65] Teller J. Le bassin de la Meuse: des défis écologiques et territoriaux transfrontaliers, Projet urbain. (2021). https://jacquesteller.wordpress.com/2021/03/04/le-bassin-de-la-meuse-des-defis-ecologiques-et-territoriaux-transfrontaliers/ (accessed March 12, 2021).
[66] Hasler S, Sicher P. Projet " ville éponge," VSA Aqua & Gas. (2021) 6.
[67] Etat de Genève, Plan directeur cantonal Genève 2030, (2021).
[68] Grisot S. Le manifeste pour un urbanisme circulaire. Rennes: Apogée; 2021.
[69] MÉMOIRES D'EAU, 2022. https://www.youtube.com/playlist?list=PLxkYxDJ6khY9uKUMlsZFjd8tHr8V92a3y (accessed July 14, 2022).
[70] Extinction Rebellion Genève, Faire Face - La Campagne, FAIRE FACE. (2022). https://faire-face.ch/campagne (accessed July 14, 2022).
[71] Jeanney B, Carlot Y. Education au risque d'inondation : comment construire la résilience des citoyens face au changement climatique? In: Recherches et Actions Au Service Des Fleuves et Grandes Rivières, 2022.
[72] Zingraff-Hamed A, Bonnefond M, Bonthoux S, Legay N, Greulich S, Robert A, et al. Human-River Encounter Sites: Looking for Harmony between Humans and Nature in Cities. Sustainability 2021;13:2864. https://doi.org/10.3390/su13052864.
[73] O.F. de l'Environnement OFEV, O. fédéral du développement territorial ARE, Eau de pluie dans l'espace urbain, (2022).