AKADÉMIAI KIADÓ

Pollack Periodica • An International Journal for Engineering and Information Sciences

17 (2022) 2, 139–144

DOI: 10.1556/606.2022.00514

ORIGINAL RESEARCH PAPER

Using nature-based solutions to support urban regeneration: A conceptual study

Qingchang He[1]* and Andras Reith[2]

[1] Marcel Breuer Doctoral School, Faculty of Engineering and Information Technology, University of Pécs, Boszorkány u. 2, H-7624 Pécs, Hungary

[2] Department of Engineering Studies, Institute of Smart Technology and Engineering, Faculty of Engineering and Information Technology, University of Pécs, Boszorkány u. 2, H-7624 Pécs, Hungary

Received: November 16, 2021 • Revised manuscript received: February 9, 2022 • Accepted: February 26, 2022
Published online: May 13, 2022

ABSTRACT

Nature-based solutions use a holistic viewpoint to address social challenges while providing environmental, social and economic benefits simultaneously. The Victoria Quay is a historical space with complex social and environmental issues. This study uses an investigation-oriented method to explore the re-planning strategies. The environmental problems are addressed by extending the green infrastructure into the site to recover the ecological corridor and alleviate flooding risks. The originally single land-use type is changed, and several historical buildings are transformed into landmarks to improve the connection with city center by linking the 'golden route'. All the proposed measures tried to reactivate the various relationships rather than merely renew the Victoria Quay.

KEYWORDS

nature-based solutions, urban regeneration, green infrastructure approach, resilience

1. INTRODUCTION

Urban regeneration is a response to the opportunities and challenges posed by urban degradation at specific times in specific locations [1]. As the evolution of the sustainable concept, urban regeneration is a comprehensive approach trying to bring solutions for society, environment and economy. Many researchers believe that the transition to urban regeneration could not be a gradual improvement process but requires a fundamental rethinking of architecture and urban design as well as the relationship with nature [2]. The European Union treats cities as a "table", which encourages Member States and Institutions to sit down and discuss the current issues of urban development; e.g., air quality, affordable houses, etc. Nature-Based Solutions (NBS) was proposed at the beginning of the 21st century, which was inspired and copied from nature. Unlike other terms, NBS is an umbrella term combining many different ecosystem-based approaches; e.g., green infrastructure, ecological restoration [3]. Using a comprehensive perspective to address the social challenges is the advantage of NBS. In addition, it is cost-effective while providing environmental, social and economic benefits and contributing to the establishment of urban resilience.

Study site of the Victoria Quay is located in Sheffield, United Kingdom. It is nearly 800 m away from the city center. There are two water features, including River Don and a canal, which brought serious flooding to the surrounding area during heavy rains in 2007. In addition, it is well known that Sheffield has a long history in the steel industry and site plays an important role in cargo distribution due to the canal and railway. Nowadays, this elevated railway is abandoned dividing the site into two sections of different functions resulting in a weak association with the city center. Moreover, the canal becomes an attractive leisure space and several historical buildings remain on the site. The current situation of the Victoria Quay is shown in Fig. 1.

*Corresponding author.
E-mail: arw16qh@163.com

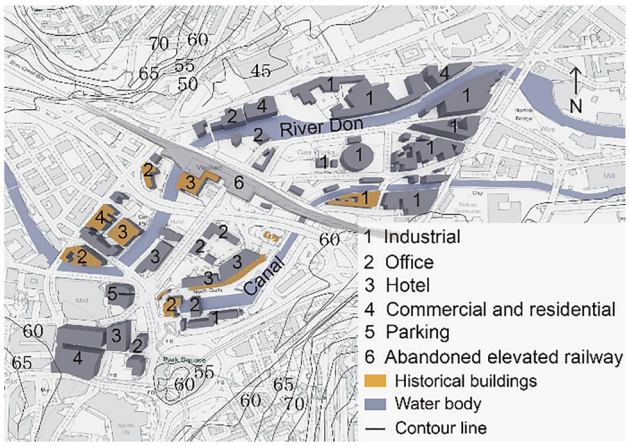

Fig. 1. The current situation of the site (*Source*: Author's plot)

2. AIMS AND METHODOLOGY

The purpose of this research attempts to explore the strategies of re-planning the study site into a resilient space through nature-based solutions. The employed methodology is based on site investigation and holistic analysis. After that, a comprehensive strategy will be proposed. The scope of the research includes,

- Investigating the current situation of study site from different aspects;
- Identifying the potential opportunities for re-activation;
- Giving holistic ideas and planning concepts;
- Considering the measures of NBS for intervention;
- Giving some detailed design interventions from landscape and architecture perspectives.

3. PROBLEM-ORIENTED METHOD

3.1. Investigating the current situation with the following perspective

- Topography and surface runoff analysis, which are usually one of the important causations of flooding. It is necessary to conduct the flood risks analysis since the site has flooded in 2007;
- Social analysis contains deprivation rate, health state and occupational grade. To some extent, this examination is equivalent to user analysis. Because the residents living nearby are the ones who use the site most frequently;
- Green infrastructure analysis. It is widely acknowledged that river corridor is a significant part of urban green infrastructure which is the framework of urban ecology [4]. It is necessary to carefully consider its existing status. Perhaps the improvement of green infrastructure is the starting point of resilience enhancement of the site;
- Landscape character analysis includes the state of green-space and architecture as well as the space atmosphere;
- Accessibility and connection analysis. The Victoria Quay is very close to the city center. It is therefore essential to investigate the connection between them, regarding the space function and attractiveness;
- Local planning policy analysis that provides a basis for later intervention.

3.2. What can be obtained from the analysis?

- The Victory quay is situated in a valley with terrain between 45 and 60 m, slopping from south to north. Most of the site have serious flood risks; especially on the north of the River Don. Furthermore, the surface runoff converges on the north of the site, which may further exacerbate the flood risks;
- The deprivation rate is nearly 30% but has medium qualification for occupation. People living on the north of River Don have a bad health rate;
- There is a limited area occupied by green-spaces, which are separated into small pieces and disconnected from each other. Vegetation is mostly grown spontaneously and appear visually monotonous;
- The character of green infrastructure is quite weak; especially the riverfront. At the same time, it loses connection with the rest of green infrastructure in the city;
- The current policies do not impose strict restrictions on re-planning, some of which encourage changes in land use and building forms;
- There is a weak connection within the site and between the city centers. Many people pointed out that there is a lack of attractiveness and public facilities, having monotonous land use, no green-space for chatting with friends; etc. But many boats with an attractive appearance are moored on the canal that appeals people to visit at the weekend. Furthermore, the existing "golden route" across the city center that links many spectacular and cultural spaces;
- The historical buildings are well managed; some of them have an attractive exterior;
- The abandoned elevated railway cuts the study site into two parts causing weak connection regarding landscape, function and atmosphere.

3.3. Summary of the problems and opportunities

The overall analysis is visualized in Fig. 2.

- The abandoned elevated railway is a barrier obstructing the functional connection between the north and south of the site. Many historical buildings are well managed in which several belong to Victorian architecture that can be regarded as landmarks; especially Royal Victoria Hotel;
- There is a serious flood risk on the site and green-spaces are small and separated into minor parts at present. It is possible that the approach of decreasing flood risk could integrate with green-space improvement;
- Riverfront has a weak character of ecology. It has potential to recover the green infrastructure connection to enhance biodiversity;
- The deprivation rate is nearly 30% and people living on the north of the River Don have a bad health rate. This

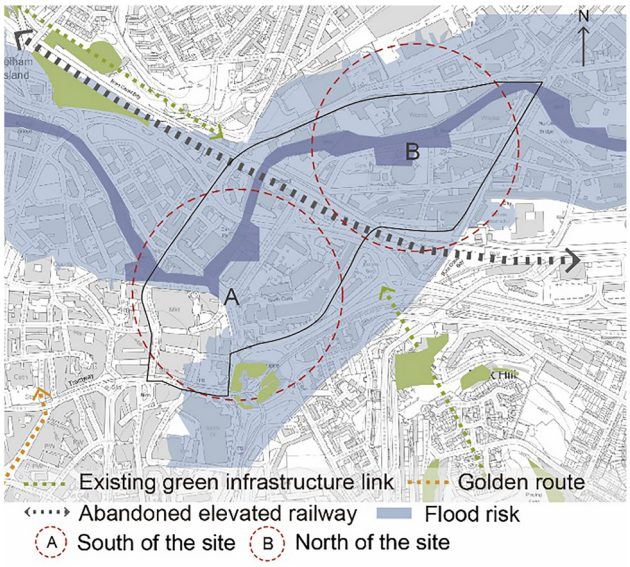

Fig. 2. Overall analysis of study site
(*Source*: Author's plot)

means that the new planning scheme requires providing some job opportunities. Meanwhile, it has long been confirmed that green-space has numerous health benefits; for example, exposure to green-space is beneficial for cognition restoration, stress relieving, reduction of diabetes and blood pressure [5, 6]. Therefore, providing high quality and well-designed green-spaces may have potential to improve the health state of residents;

- At present, the Victoria Quay has low attractiveness but has historical value and is close to the city center. More importantly, the existing "Golden route" is used by many residents and tourists. It has potential to extend this special route into site to connect the landmarks (famous historical buildings) and the area around the canal.

4. CONCEPT

Previous steps have demonstrated that study site has complicated environmental and social issues, which limits the further development of the Victoria Quay. Consequently, improving these two aspects is the major concern of this study. The vision of re-planning is to transform the study site into a resilient space in the aspects of economic, social, and environmental dimensions. Study employs the word 'permeability' to represent the concept, which means that these three aspects should influence and complement each other in the re-planning process.

4.1. The idea of permeability in the aspects of function, ecology and connection

Improving the connection within the site and between the city-center is the focus of social aspect. So as to achieve this, the single land use type on the north of the site is transformed into a mixed land use type. The abandoned elevated railway divides the site into two different functional spaces. There is a friendly atmosphere and mixed land use type on the south of site. On the contrary, the land use on the north of the site is dominated by industries that occupied the valuable land on the riverside while the dilapidated warehouses and factories bring a sense of insecurity to the residents and visitors. Enhancing the functional connectivity within the site could not only improve the internal integrity of the site but also provide a chance for the subsequent improvement of the association with the city center. In addition, mixed land use type usually contains office, commerce, residence and industry that will provide more job opportunities, compared with single land-use type. To some extent, this could alleviate the problem of poverty in the study site.

In terms of the connection improvement with city center based on the former functional connection enhancement measures, it is significant to further strengthen the association from the macro perspective. As it was mentioned before, the existing 'golden route' of Sheffield starts from the railway station and ends at the Sheffield cathedral, which links many public open spaces and famous historical buildings; e.g., Peace Garden, Sheffield Town Hall. As a result, this unique route is prolonged to the site. Several spaces and buildings with potential for renovation are recognized as landscape nodes (Fig. 3).

Regarding the environmental aspects, there is a serious flood risk on the site as formerly described. Generally speaking, land use, cover pattern and rainwater infrastructure enable seemingly similar urban communities to experience very different flood patterns in the same storm event [7]. This means that storm-water management needs a multi-scale perspective. Building embankments on both sides of the river or constructing large-scale storm-water facilities in the flood zone are the most common response measures. Although this can alleviate the risks to some extent, it also seriously damages the image of the city. In ecosystem services, water flow regulation and flood control could potentially be executed. The riparian ecosystem could be properly designed and managed by implementing cisterns

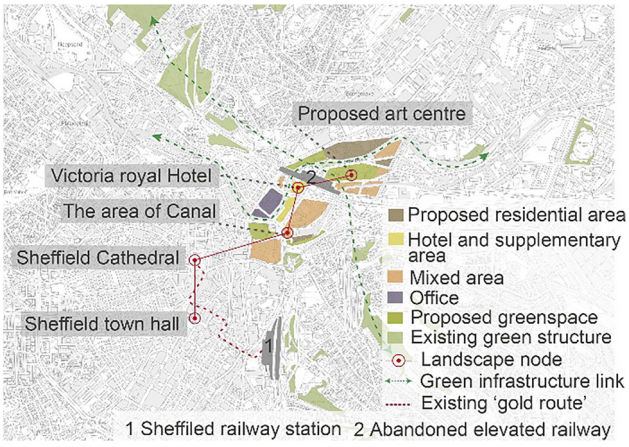

Fig. 3. Strategic master-plan for connection enhancement
(*Source*: Author's plot)

on the site, increasing the rate of rainwater seepage and re-naturalizing the current over-engineered waterways [8]. Accordingly, study will mitigate the flood risks by using NBS. Green infrastructure approach is an important component of NBS, which considers the conservation value, land development, growth management and built infrastructure planning [3]. Green infrastructure-related approaches; like, rain gardens and street linear tree systems all have the potential to alleviate flood risk. They could improve retention capacity through vegetation cover, increasing storage capacity and soil penetration, thereby reducing surface runoff [9]. Besides, it is well known that green infrastructure is strongly related to ecosystem services that can provide numerous ecological benefits; for instance, providing habitat for birds and insects, improving biodiversity by fostering diversified biological groups. This implies that addressing the problems of flooding and ecology can be considered as a whole. Furthermore, the rejoining of the green-space will improve the aesthetic quality of the site, and then attract enterprises and companies to settle down. This could provide many potential job opportunities to the neighborhood residents.

4.2. The landscape and architecture interventions in 'permeability'

4.2.1. Renovating the riverfront warehouse. As former described, the current riverfront is occupied by several warehouses, which bring a sense of insecurity to the public. Renovating these old facilities and integrating them with ecological character could promote the attractiveness of the river corridor. In addition, transforming these warehouses into post-industrial landscape is another way to reflect sustainability.

4.2.1.1. Cutting the elongated building form of the warehouse. The riverbank has a warehouse of over 120 m, severely blocking the direct view to the river and restricting access to the river. This warehouse is made of red materials and many steel frames are supported the interior spaces. The first transformation idea is changing the elongated building form to improve accessibility. Therefore, part of the exterior walls and structure were demolished, and the original strip form was split into two pieces. In addition, the original roof was removed to increase the light in the interior space.

4.2.1.2. Maintain the steel frame and add green character to the renovation. The remained steel frames are tidily arrayed inside of the warehouse but lack vitality. Thus, study used many meshes to connect these steel frames on the top of the warehouse. This could provide a carrier for the spread of vines, and the combination of grids and plants makes the shadows on the ground more vivid (Fig. 4). In addition, urban agriculture is also utilized in the redesign process, which not only enhances the interest of the new warehouse but also delivers an opportunity for children to contact with the growth of wheat that process is important for children to learn from nature. Besides, many supplementary facilities were also designed in this warehouse; e.g., badminton courts and benches.

Fig. 4. The visualization of the new warehouse (*Source*: Author's plot)

4.2.2. Transforming the leaf vein garden and riverside into landscape node. As mentioned before, the area around the canal is the only attractive leisure place in the Victoria Quay but on small scale. It is necessary to strengthen the landscape character in the longitudinal direction to improve the attractiveness of the site and enhance the connection with city center. Therefore, the area around the riverfront and the circle building is the focus of the renovation.

4.2.2.1. Removing parts of the embankment and extending the urban life to the riverside. Riverfront is usually a fantastic place to connect the urban life with the natural landscape. To end this, part of the original embankment is removed to expand the view along the river and several water affinity platforms are set in the shallow water areas (Fig. 5). In addition, many discarded materials are reused for building furniture or landscape facilities; e.g., rail, bench and flower pond. Moreover, many water-tolerant trees and meadows are employed for improving the ecological character.

4.2.2.2. The design of leaf vein garden. On the north of the site, there is a circle building located between the canal

Fig. 5. The visualization of new riverfront promenade (*Source*: Author's plot)

and the river Don. Transforming it into an art center (new landmark) in the site could provide an extra place for public to visit. The adjacent area of the circle building was redesigned as an ecological square to form an attractive open space by connecting the riverside promenade at the north and south ends. It is widely accepted that public space provides an essential role in the daily life of an individual encouraging people to engage in social life [10, 11]. The design form of this square comes from a leaf vein, which means that it is cut into blocks with different sizes; wherein the flower gardens, lawns, small woodland and children's playing fields are filled with these irregular shapes. Furthermore, this design form, to some extent, reflects the proud background of Sheffield, the greenest city in Britain.

4.3. Application of nature-based solutions to environmental issues

Based on the new land-use strategy (Fig. 6), research divided the specific measures into several steps. Firstly, increase the green ratio to capture and absorb the surface runoff. The Victoria Quay is situated in a valley that results in the surface runoff tend to flow into the site. Moreover, the majority of surface is covered by concrete and asphalt. These impervious surfaces often prevent rainwater from seeping into the ground but run off into the sewers and quickly into local water-body or low-lying areas, resulting in local waterlogging. Therefore, the original large amounts of hard surfaces are substituted by green-spaces and pervious pavements. In the proposed residential area on the north of the River Don, a new multi-functional space is created. This means that this shallow funnel area is used for daily activities in normal weather; however, it could collect rainwater in a short time to protect the surrounding buildings during heavy rains. Moreover, green roofs and rain gardens were installed on the buildings and streets to further collect and store portions of surface runoff and slow down the speed of influx. It is widely acknowledged that green roof could decrease the peak rates of runoff and have the ability to capture a certain volume of rainwater from each rainstorm.

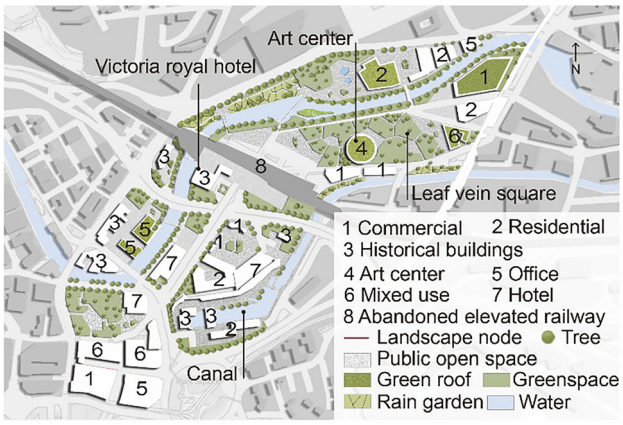

Fig. 6. New land use and green infrastructure (*Source*: Author's plot)

Study by [12] found that green roofs in Germany could retain nearly 40%–100% of the runoff although this depends on the season. As a natural or artificial shallow depression, rain gardens will converge and absorb the rainfalls from streets and roads during the tiny rain, then purifying it through vegetation and sand, after that it will seep into the soil to replenish and maintain the underground water. This could not only alleviate flood risk but also preserve the balance between ground and underground water. Moreover, green roofs and rain gardens are also beneficial for biodiversity improvement.

Another measure is that restore the ecological corridor along the river through tree corridor and group of species (Fig. 6). This is beneficial for natural habitats restoration and protecting the self-sustainability of species. The richness of plant species is highly dependent on vegetation structure [13]. Vegetation structure refers to the canopy height, leaf area index and aboveground biomass. In this regard, the ecological communities along the river have at least three layers and many species with high visual quality and water-tolerant properties are used; e.g., Ginkgo biloba, Goldsturm, Persicaria affinis. This could encourage fostering diversified biological groups creating splendid landscape visual impact and converging all kinds of biological resources; for example the endangered plants and herbs. It also provides food and shelter for animals and other organisms. In addition, as mentioned before, the adjacent area of proposed art center is redesigned as an ecological square connecting the canal and River Don that could longitudinally reinforce the character of green infrastructure. Meanwhile, along with the proposed green roofs, rain gardens, and green spaces, the flood risk could be alleviated by this series of mitigation systems.

5. CONCLUSION

This research is a conceptual study of using nature-based solutions to support urban regeneration. As an area with historical value, the development of Victoria Quay has been restricted because of the single land use type, high flood risk, low attractiveness, low ecological features and weak relationship with the city center. These problems also bring negative impacts to neighborhood residents; for example, high deprivation rate, low healthy state. As a result, exploring the resilient strategies of improving the social and environmental aspects are the main concerns of this study. By strengthening the functional connections within the site, the mixed land use types will partly weaken the side effect of site division by the abandoned elevated railway. Meanwhile, it also improves the internal integrity of the site and provides many employment opportunities for residents. Based on this step, research extends the unique 'golden route' of Sheffield to the site; also, the area around canal and the historical building of Royal Victoria Hotel as well as the proposed art center as the landscape node of the new route. This could improve the relationship with city center and enhance the popularity of Victoria Quay from a macro perspective. In addition, several original buildings have been demolished or

transformed in order to provide spaces for river ecological corridor extension and riverfront visibility improvement. As for environmental issues, study integrates flood management and ecological improvement into consideration. Nature-based solutions related green infrastructure approach is employed to address these problems through increasing green ratio, installing green roofs and rain gardens as well as restoring ecological corridor along the river. Those measures stimulate the Victoria Quay to reactivation from social and environmental aspects. Lastly, this research provides a platform for landscape and architecture designers to get involved in urban regeneration while providing many useful ideas for local authorities.

ACKNOWLEDGEMENT

Qingchang He is very grateful to his classmates who have a similar research topic and giving some suggestions.

REFERENCES

[1] P. Roberts and H. Sykes, Eds, *Urban Regeneration: A Handbook*. Sage Publ., 2008.

[2] S. Jenkin and M. P. Zari, "Rethinking our built environments: Towards a sustainable future," Research report for the Ministry for the Environment, New Zealand Government, Wellington, New Zealand, 2009.

[3] E. Cohen-Shacham, G. Walters, C. Janzen, and S. Maginnis, Eds, *Nature-based Solutions to Address Global Societal Challenges*. Gland, Switzerland: IUCN, 2016.

[4] L. A. Baschak and R. D. Brown, "An ecological framework for the planning, design and management of urban river greenways," *Landscape Urban Plann.*, vol. 33, nos 1–3, pp. 211–225, 1995.

[5] P. James, R. F. Banay, J. E. Hart, and F. Laden, "A review of the health benefits of greenness," *Curr. Epidemiol. Rep.*, vol. 2, no. 2, pp. 131–142, 2015.

[6] J. Maas, R. A. Verheij, S. de Vries, P. Spreeuwenberg, F. G. Schellevis, and P. P. Groenewegen, "Morbidity is related to a green living environment," *Epidemiol. Community Health*, vol. 63, no. 12, pp. 967–973, 2009.

[7] T. Bai, A. L. Mayer, W. D. Shuster, and G. Tian, "The hydrologic role of urban green space in mitigating flooding (Luohe, China)," *Sustainability*, vol. 10, no. 10, 2018, Paper no. 3584.

[8] R. M. Pulselli, S. Broersma, C. L. Martin, G. Keeffe, S. Bastianoni, and A. van den Dobbelsteen, "Future city visions. The energy transition towards carbon-neutrality: lessons learned from the case of Roeselare, Belgium," *Renew. Sustain. Energ. Rev.*, vol. 137, 2020, Paper no. 110612.

[9] E. Zimmermann, L. Bracalenti, R. Piacentini R, and L. Inostroza, "Urban flood risk reduction by increasing green areas for adaptation to climate change," *Proced. Eng.*, vol. 161, pp. 2241–2246, 2016.

[10] Q. He and A. Reith, "Potentiality of a residential area: Practical design at Brigittaplatz," *Pollack Period.*, vol. 16, no. 3, pp. 158–163, 2021.

[11] C. Lu, H. He, T. Zhao, A. Borsos, and J. Gyergyak, "The potential of residential area – A practice design at Roissypole," *Pollack Period.*, vol. 16, no. 1, pp. 157–161, 2021.

[12] Storm water runoff - green infrastructure stemming the flow in cities. [Online]. Available: https://livingroofs.org/storm-water-run-off/. Accessed: Oct. 16, 2021.

[13] U. Schadek, B. Strauss, R. Biedermann, and M. Kleyer, "Plant species richness, vegetation structure and soil resources of urban brownfield sites linked to successional age," *Urban Ecosyst.*, vol. 12, no. 2, pp. 115–126, 2009.