5. Resi^2 Rick: Flood Resistance and Resilience in Ricklingen, Hanover (Germany)

A proposal for future development potentials

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Abstract

This paper explores how factors of flood resistance and resilience are addressed within the development of an area in Ricklingen, a hydro-geologically vulnerable district in the southwest of Hanover. The already existing dyke as a flood control and resistance measure offers protection against fluvial floods but does not offer protection for pluvial or flash floods and further intensification of extreme weather events. In order to adapt to climate change, this paper proposes the establishment of ditches that relieve stress from the drainage system and ponds and green roofs to evacuate intense rainfalls. The City of Hanover has already established a transparent information base on flood precaution, response and recovery and initiated a funding programme for roof and facade greening and land reclamation. In addition to these measures, this proposal foresees awareness-raising campaigns, resilience meetings and supplemental incentive schemes to encourage civil initiatives and actions such as small retention basins on private property. Besides, the high recreational value of the landscape should be further strengthened to support a close connection between people and nature.

1. Introduction

Since time immemorial, access to water supply, water-related transport services, fertile soils and the charm of living near rivers and coastal areas have led to extensive development in regions at risk of flooding (OECD 2016: 12). In 2016, 50% of natural catastrophes had been hydrological events (Munich Re 2017: 54), and progressive climate change is expected to generate a further increase in the level of flood risk brought about through rising sea levels, torrential rainfalls, storms and storm surges (OECD 2016: 12). Using the example of a small area in the German city of Hanover, this research explores the critical factors of flood resistance and resilience and expands on the question, how concrete protection and adaptation measures can be adopted in urban landscapes and practical processes.
The area under investigation is situated in the district of Ricklingen in the southwest of Hanover (see Figure 1). Besides its incorporation in 1920, the district has preserved some of its rural village character and rustic settlement structure. The river Ihme, the nearby lakes, and the attractive landscape conservation area surrounding it provide great potential for recreation but can also pose flood risks to the local population (Fidele Dörp 2005: www).

In addition to the Ihme, the river Leine is crossing the city of Hanover and flooding is a problem that has been around for a considerable time. The importance of addressing this phenomenon has been recognized early on and already in 1449, a ditch as a measure against the floods was mentioned in historic documents (Region und Landeshauptstadt Hannover 2019c: www). With progressive urban development and the attendant loss of natural floodplains, the need for further protection measures became inevitable which led to the establishment of special precautions in forms of dykes and dams as well as a contingency plan by the fire department and the municipal drainage operation. Furthermore, the necessity for flood protection has been incorporated on the administrative level and is being considered in urban land use planning of the city (ibid.). This paper develops a number of additional measures in order to build a solid foundation for continued protection and resilience in the future.

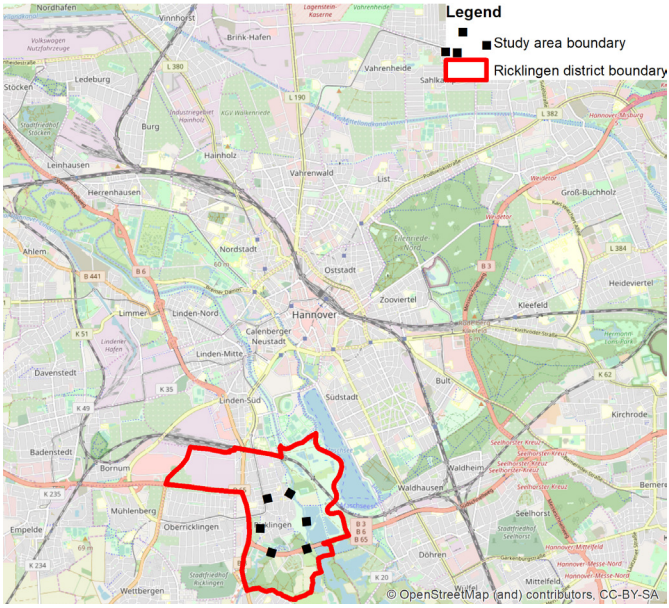

Fig. 1. The district Ricklingen in the southwest of Hanover (own depiction based on Landeshauptstadt Hannover 2019: www; Openstreetmap.org 2019: www)

In the following chapter 2, the topic will be introduced in more detail by outlining the concept and methodology on which this research developed. Subsequently, chapter 3 provides insights into the area under investigation situated in the district Ricklingen, introduces flood risks and already existing protection measures. Based on the outcome of this analysis and based on the findings of previous research and projects as provided in chapter 2, a design proposal for flood resilience measures will be presented (chapter 4) as well as governance mechanisms that can be introduced into the political process to increase private action and initiatives and can be promoted through incentives such as tax breaks (chapter 4.3). Finally, in chapter 5, the design and results of this research will be reflected, and some concluding remarks will be given.

2. Contextualisation

Amongst others, the British Natural Environment Research Council proposes five types of flooding, i.e., coastal/ tidal, river/ fluvial, groundwater, surface water/ pluvial and flash floods (Nerc & Gilliland 2017: www). Thereby, coastal/ tidal floods are associated with heavy storms and high tides that inundate

coastal areas and protective levees and dykes, whereas rises in the level of groundwater specifically endanger underground infrastructure such as cellars and tunnels (ibid.). A fluvial flood is caused by a river overflowing its banks due to heavy rainfall or a thawing period, spreading large quantities of water over its floodplain and especially in urban areas, the resulting damage can be correspondingly extensive (ibid.). Surface water or pluvial floods are associated with heavy rainfall resulting in an overload of the drainage system. The problem is further intensified by the predominance of impermeable grounds in cities, which also offers optimum preconditions for flash floods that can develop very rapidly and refers to a downflow of water and respectively an inundation of subjacent areas (ibid.).

According to the Urban Flood Community of Practice, strategies to address the challenges of flood risk should include regulatory, financial, economic and behavioural implementation tools (UFCOP 2017: 9). On a regulatory level, building, zoning and emergency plans can bring clarity and may be consulted by the population in case of new construction or rebuilding of houses. Appropriate insurance for (private) buildings and ground in flood-prone areas is an essential factor for livelihood security and should be supplemented by the provision of public funding sources (ibid.). Awareness-raising and capacity building initiatives serve the purpose of establishing solid knowledge and information and change public awareness and behaviour in the long term - a process that can be accelerated significantly utilising economic implementation tools such as tax incentives (ibid.).

Within flood risk management, a distinction is being made between flood resistance and resilience. The latter can be measured by the 'flood ability' of a city, i.e., the capacity of a city to maintain its overall functions (e.g., secure human subsistence, economic performance and transport network) despite flooding and, in case of damage, the speed of reconstruction and rehabilitation of the city (Kuei-Hsien 2012). The focus of resilient flood management strategies is on impact reduction utilising prevention and preparation measures, whereas flood resistance focuses in particular on the development of precautionary measures to decrease the risk and danger of flooding

(Gersonius et al. 2016). Thereby, measures that primarily serve to control or resist floods, such as levees, dykes and dams, are considered to only partially address the increased severity and frequency of hydrological weather events (Kuei-Hsien 2012).

Methodology

The contextualisation of flooding and the associated risks, concepts and strategies as outlined above, forms the theoretical basis for the scope of this research. A thorough investigation of the territory is essential to ensure appropriate outcomes. In this sense, literature such as reports and articles, as well as statistical data on the population, building structure and nature of the terrain, were harnessed to portray the local conditions. A GIS-based spatial analysis was compiled to provide an in-depth overview of the territory and visualise different flood scenarios and display the already existing flood control measures. In the context of this research project, several maps of the area were made using the GIS-software ArcGIS 10.6.1 (chapter 3). Furthermore, an urban stroll has been conducted by members of the research team in July 2019 to gain a good overview of the local opportunities and challenges. Following an explorative approach and based on these findings and experiences, a design proposal for flood resilience on the survey site has been developed and will be presented in chapter 4.

3. The Study Area in Ricklingen

The study area is located in the urban district Ricklingen. It does not cover all territory of urban district and has the size of 0,80 km^2 while the area of the whole urban district is 4,78 km^2 (Landeshauptstadt Hannover: 102). The part of Ricklingen where the survey took place is situated to the south of the center of Hanover, close enough to the city border.

The river Ihme flows through the study area. It discharges into the river Leine in the north-west of Hanover center. Leine runs in the distance of no more than 1 km from the eastern boundary of Ricklingen. To the west from the investigated territory, the pond Großer Ricklinger Teich lies between riverbed of Ihme and Leine. It is one of gravel ponds Ricklinger Kiesteiche. They were established in the place of gravel carriers. The study area consists of a connectedly built-up zone and territory dominated by woodland and grassland with few detached houses. Unde-

veloped part lies within the floodplain of rivers Leine and Ihme (Region und Landeshauptstadt Hannover 2019b: www).

The most common building type in the investigated territory is dwelling house. Apartment buildings differ from each other by size and number of floors. In the western part of the built-up zone within the study area, there are a lot of multi-apartment houses mostly of three to five storeys. In the eastern part multi-storey brick houses with attics and few apartments are prevalent. Area without dwelling houses that is located close to river Ihme is generally covered by forest or meadows. Few buildings, such as swimming pool with café and little outbuildings ("Ricklinger Bad") and the group of summer houses that are not suitable for year-round residence, were constructed there. Allotment garden houses are located between the river Ihme and highway B65 which is the southern border of the study area. In the opposite bank of the river from summer houses, adjacent to the built-up zone, the cemetery Michaelis-Friedhof is situated.

Within the built-up zone, some houses that are higher than surroundings on average are observed. The multi-apartment building in the corner of streets Kneippweg (house numbers 1-7) and An der Bauerwiese (house numbers 11-17) has total length of more than 300 meters, and some its sections have a height of 12 storeys. Another example is multi-apartment building Stammestrasse 16 in the eastern part of the built-up zone. This house of six storeys is surrounded mostly by buildings of two to three storeys. In general, the building Kneippweg 1-7/An der Bauerweise 11-17 is the only house that really stands out of other constructions by size.

The part of Ricklingen described above faces the risk of flooding due to the overflow of rivers Leine and Ihme. The headwater of Leine is located in southern Harz mountains in Thuringia and the source of Ihme is situated in Deister chain of hills in Lower Saxony to the west of Hanover. In springtime because of snowmelt and increased precipitation, the water level of these rivers grows significantly. That can lead to flooding.

After the end of World War II, Hanover faced with several floodings. The most destructive one occurred in 1946 when the whole investigated territory was flooded (Neue Presse 2012: www). In 1954 the first dyke in Ricklingen was constructed (Region und Landeshauptstadt Hannover 2019c: www). Less damaging floodings were observed in 1981, 2003, 2007, 2013 and 2017 years (Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- Und Naturschutz 2013: www; Hannoversche Allgemeine Zeitung 2017: www).

In Lower Saxony, three scenarios of flooding around the riverbed of Leine were predicted. These scenarios are based either on forecast or on statistics of the previous flooding. The scenario HQ100 displays the freshet that occurs once in 100 years statistically. HQ200 is the scenario of extremal flooding. HQ25 as the scenario of high probability displays the average level of flood that occurs once in 25 years (see Figure 2). Map of HQ100 displays approximate flood lines in 1946 (see Figure 3), while overflows of HQ200 (see Figure 4) level never happened

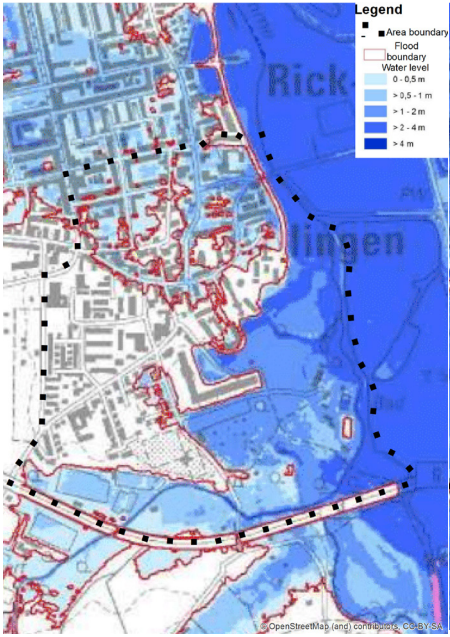

Fig. 2. Study area in Ricklingen within the zone of HQ25 flooding (own depiction based on Openstreetmap.org 2019: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019b: www)

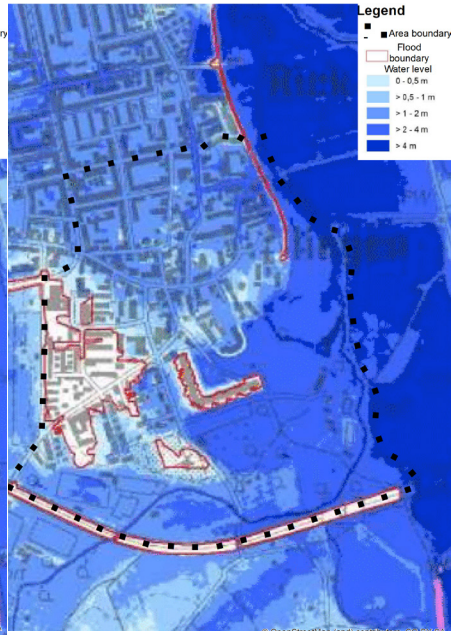

Fig. 3. Study area in Ricklingen within the zone of HQ100 flooding (own depiction based on Openstreetmap.org 2019: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019b: www)

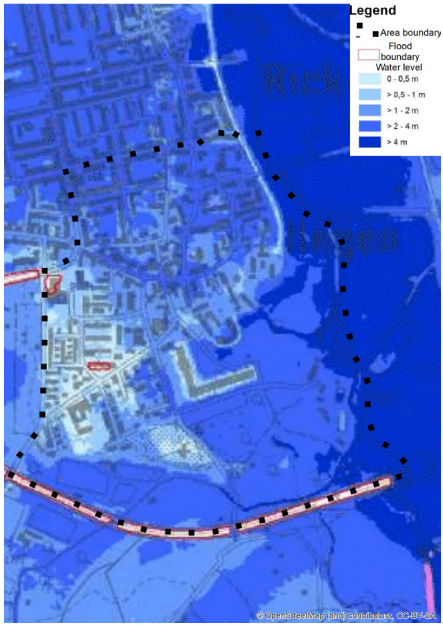

Fig. 4. Study area in Ricklingen within the zone of HQ200 flooding (own depiction based on Openstreetmap.org *2019: www;* Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz *2019b: www)*

during the history of monitoring (Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019a: www). As can be concluded from the maps below, according to HQ25 scenario only the northern part of the built-up zone within the study area will be flooded while following HQ100 scenario only its south-western part will not be covered by water.

The dyke between the built-up zone and meadows is the main object that protects Ricklingen from flooding. It firstly appeared in 1954. During the last decade, it was reconstructed. The renewed dyke Ricklinger Deich was inaugurated in 2018. Ricklinger Deich is a fortified embankment with several gates between its parts. Within the investigated territory, it lies in immediate proximity from dwelling houses (see Figure 5). It has three gates that can be closed before heavy flooding. In the south of the study area, part of Ricklinger Deich is the wall of the cemetery simultaneously. Objects that need strengthened protection of flooding are: 1) the chapel Edelhofkapelle, the oldest church in Hannover which was built XIV century (Michaeliskirchengemeinde Hannover-Ricklingen 2015: www); 2) half-timbered houses that are more vulnerable to the influence of water due to features of their construction material; 3) cemetery where the ptomaine may come up in case of strong overflow.

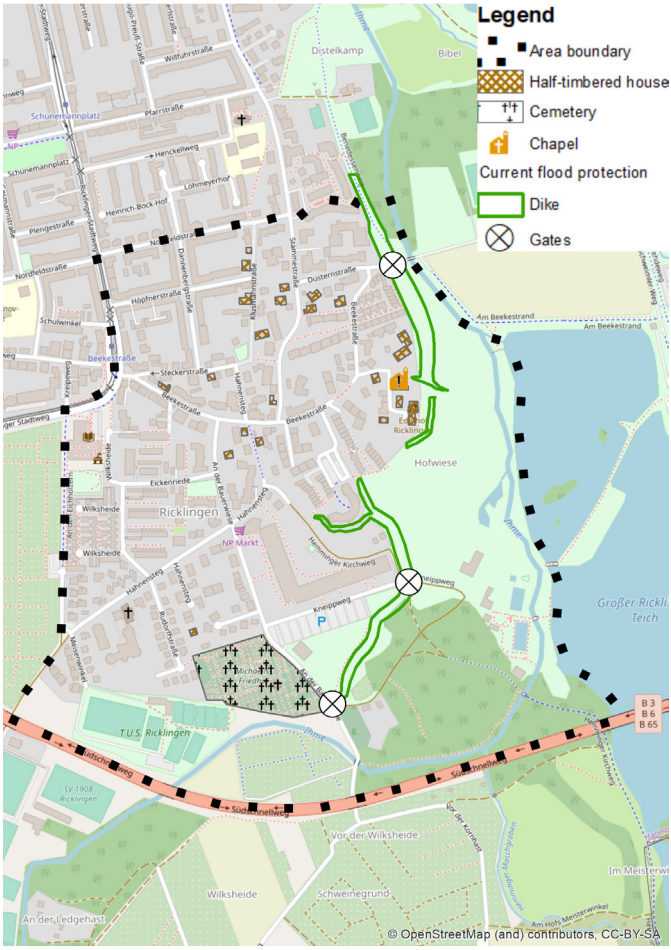

Fig. 5. Current flood protection and objects especially vulnerable to flooding (own depiction based on OpenStreetMap.org 2019: www)

4. Design Proposal for Flood Resilience in Ricklingen

For the future of Ricklingen, a proposal was formed through the following process. First, it was established as a vision through a status survey for the flood resistance, which Ricklingen aims to achieve in the long-term. A total of four principles were conceived to apply the vision to the target area as follows:

1. Water storage space to accommodate sudden events with heavy rainfall
2. The system that connects the flow of water from inside and outside areas of the survey site

3. Strategy applicable to individual buildings in the area
4. Application of multi-purpose recreation by an understanding of the natural context

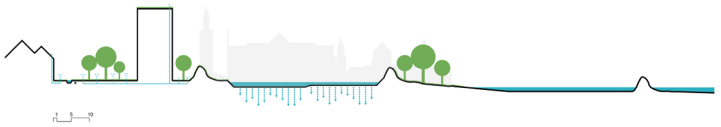

Fig. 6. Design and topography of the target area (own depiction)

Based on the direction of each principle, the measures suitable for the target area are planned with specific action plans (see Figure 6). The existing dyke in Ricklingen as flood control and resistance measure offers protection against fluvial floods but does not provide for flash floods and further intensification of extreme weather events. For adapting to climate change, the proposed measures include ponds at the inside and outside areas, as well as, ditches that relieve stress from the drainage system in the area. Besides, as individual strategies for private and public perspectives, it can be considered planting works on each building with a flat roof to evacuate intense rainfalls, and the high recreational value of the landscape will be further strengthened to support a close relationship between people and nature in Ricklingen (see Figure 7).

Fig. 7. Proposed measures and their location (own depiction)

Temporary Water Storage Space

Ricklingen's contour level of the land is not much different from the nearby lakes. For this reason, torrential rain could indeed cause flooding problems in the investigated area. According to the physical situation, the priority should be considered how to cope with temporary events with torrential rain. Although there are flood problems to consider in Ricklingen, drainage facilities have been identified in the field survey to a general level that is not as special as in any other region. Thus, plans are presented to supplement existing facilities. One measure is to install several ponds with basins inside and outside of the area. Each pond temporarily stores rainwater during torrential rains and splits it away after the rain stops or allows the water to be utilised for such as cleaning and landscaping. Besides, rainwater that suddenly swelled due to torrential rains is stored at various locations at the same time, so that it is adequate to supplement the drainage capacity to prevent flooding in the survey site. Especially since Ricklingen has a variety of allotment gardens, it may be possible to consider using rainwater in conjunction with the gardens.

Fig. 8. Multipurpose playground and rainwater storage (own depiction)

The location to install these ponds which are developed to retention basins can be divided into the inside and outside area of Ricklingen. First of all, it is possible to utilise the playground spaces in the case of the inside area. Under general weather conditions, playgrounds that are environmentally friendly as children's activity areas can be changed to open spaces for effectively storing rainwater in urgent situations such as torrential rain (see Figure 8). Through the field survey, a total of 6 playground spaces could be identified within the area, and if the direction to be shared for the local residents' private spaces is given, more space of possibility will be expected in the future. In the case of the outside area of the territory, the large-scale landscape area, which has been neglected, could be used temporarily as a facility for the low-lying area. Above all, this landscape area is located between the inside area and the lakes nearby so that it is suitable as a buffer zone to control the mutual effects of flooding.

Water Network System

As described before, Ricklingen's drainage facilities are at a general level. The rainwater is possible to be pumped directly into the soil in the outside areas of the dyke. But in the case of inside areas, there is a large amount of drained surface which

has been covered by asphalt and blocks with development of residential district. In this situation, the water moves to the nearby river basin while the water drifts to the ground impermeable surface during heavy rainfall. However, the gates are closed at urgent events such as torrential rain, and the flood risk of the inside area is increased. Therefore, a well-planned water network system should be designed and be related to the temporary water storage spaces which are proposed before.

Fig. 9. Proposal for ditches (own depiction)

The proposal for the water network system is to make ditches in the entire area of the site (see Figure 9). It is not a function for the movement of rainwater but also a linear system that allows self-absorption to proceed smoothly from the ground surface to the soil. In some cases, it connects the water drainage inside and outside of the territory and controls the flow rate itself. Moreover, Ricklingen can be expected to have a positive effect in terms of complementing the general functions of existing drainage facilities.

Individual Strategy

The appropriate strategies are suggested together at the individual level for the flood resilience in Ricklingen. First, the strategy of greening on roofs and walls of individual houses and public buildings expected to perform as an effective function of quantity control of rainwater. Above all, a green roof system

can temporarily store water like the pond, which was proposed, so that has the advantage of no leaking copious amounts of water in a short time. Therefore, it is possible to devise an environmental strategy in which individual members of society can participate by actively linking the green space of individual buildings with the ponds in the area. Also, each resident can independently make a temporary water storage space for the public benefit if there is an open space. Such individual efforts for the public may be compensated by municipalities on private real estate through incentive policy. The virtuous cycle structure of the area can be expected to get positive effects not only on the flood resilience strategy but also on the development of Ricklingen itself.

Under the name “Begrüntes Hannover”, the City of Hanover has already launched a funding programme for the greening of roofs and facades and de-paving of urban areas (Region und Landeshauptstadt Hannover 2019a: www). This incentive scheme could be expanded so that the ponds are eligible for funding as well. Furthermore, awareness-raising campaigns and resilience meetings can enhance the civil preparedness for hydrological events and create the basis for environmental literacy. Like the construction of new buildings, house rebuilding should be coupled to specific structural and ecological requirements to progressively increase the system robustness of the area at all levels.

The existing dyke and outside area of Ricklingen were understood as a landscape with abundant recreational value through the field survey. Some areas have been used as a function of a seasonal outdoor swimming pool by the city of Hanover, but the green areas which occupy a large proportion that are preserved without any special functions. If the high potential areas can be utilised as a park, cycling routes, and external community spaces, it will be possible to induce the active participation of residents for public development.

Conclusion

In conclusion, floods, resulting in life loss and huge damages, have always occurred and will continue to do so. Consequently, there is an urgent demand for reaction, especially while taking into consideration the further increase of flooding due to the se-

rious climate change the planet is facing. However, despite the inevitable character of the problem, appropriate planning and adoption of efficient measures may still have the power to influence the extent of the phenomenon, and, most certainly, their impact on society, in response to the greater need for resilience in our surroundings.

Resilience, defined by Bruneau et al. (2003), as "the ability of social units (e.g., organizations, communities) to mitigate hazards", is considered to be a powerful tool, as "it contains the effects of disasters when they occur, and carries out recovery activities in ways that minimise social disruption, and mitigate the effects of future disasters" (Bruneau et al. 2003). Living with water requires innovative architectural and planning solutions. Success can only be reached if an interdisciplinary approach is adopted in the development of an integrated strategy towards flooding mitigation. In integrated approach for resilience consists, therefore, of processes and strategies that engage design, planning and engineering, along with social and political solutions to proactively adapt to and live with nature. The best strategy for a particular area, needs always to take into account technical feasibility, financial constraints and environmental considerations, as well as political and societal acceptability.

In the present paper, the development of the proposed strategy started with a proper understanding of the flood risk in the given study area and its surroundings, based on a GIS-based spatial analysis for the visualisation of possible flood scenarios and the investigation of the existing flood control measures. In accordance with the concept of integrated planning, the practices proposed, aim mostly at the retention of excess water amounts caused by pluvial flooding, as well as fluvial and flash floods, rather than at the implementation of further structural protection measures. As a result, a proposed network of waterways running through the intervention area guides the water towards and into small ponds, spread throughout the neighbourhood, which serve as water storage spaces. Adapted to certain particularities, some individual action plans were considered, in a number of buildings that could accommodate green roofs, contributing further to water retention.

At the same time, the ultimate aim of the resilient strategy was to raise awareness of the issue and ensure public participation. Therefore, in accordance with the natural context, multi-purpose recreational activities and spaces are proposed, as an addition to the technical part of water guidance and retention measures, in order to invite, not only the local, but also the surrounding community and engage their interest in protecting the place.

Bibliography

Bruneau, M., Chang S.E., Eguchi R.T., Lee G.C., O'rourke T.D., Reinhorn A.M., Shinozuka M., Tierney K., Wallace W.A. & Von Winterfeld D., 2003: A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. Earthquake Spectra, Vol. 19, No. 4, 2003, pp. 733-752.

Fidele Dörp, 2005: Fidele Dörp | Gegenwart | Der Deich in Ricklingen, http://www.fidele-doerp.de/gegenwart/deich.html, last accessed: 22.07.2019.

Gersonius, B., Kelder, E., Van Buuren, A. & Zethof, M., 2016: Resilient flood risk strategies: institutional preconditions for implementation, Ecology and Society 21 (4): 28, https://doi.org/10.5751/ES-08752-210428, last accessed: 20.07.2019.

Hannoversche Allgemeine Zeitung, 2017: Nur noch eine Straße ist gesperrt, https://www.haz.de/Hannover/Aus-der-Stadt/Uebersicht/Hannover-droht-nach-Dauerregen-das-Rekord-hochwasser, last accessed: 01.08.2019.

Kuei-Hsien, L., 2012: A Theory on Urban Resilience to Floods - A Basis for Alternative Planning Practices, Ecology and Society, 17 (4): 48, http://dx.doi.org/10.5751/ES-05231-170448, last accessed: 20.07.2019.

Landeshauptstadt Hannover, 2018: Sachgebiet Wahlen und Statistik - Strukturdaten der Stadtteile und Stadtbezirke 2018. Landeshauptstadt Hannover: Hannover

Landeshauptstadt Hannover, 2019: Geoinformation 2019. URL: https://www.hannover-gis.de/GIS/index.action. Last accessed: 03.10.2019

Michaeliskirchengemeinde Hannover-Ricklingen, 2015: Die Geschichte der Michaeliskirche und der Edelhofkapelle, http://www.michaelis-hannover.de/artikel/2015/01/michaeliskirche-und-edelhofkapelle.php, last accessed: 01.08.2019

Munich Re, 2017: Topics GEO - Natural catastrophes 2016. Analyses, assessments, positions. Munich: Münchener Rückversicherungs-Gesellschaft, https://www.munichre.com/site/touch-publications/get/documents_E711248208/mr/assetpool.shared/Documents/5_Touch/_Publications/TOPICS_GEO_2017-en.pdf, last accessed: 30.07.2019.

Nerc & Gilliland, B., 2017: Flooding Infographic | What causes it and what are we doing to prevent it? https://nerc.ukri.org/planetearth/stories/1856/flooding-poster/, last accessed: 02.08.2019.

Neue Presse, 2012: Hannover fürchtet sich vor dem großen Hochwasser, https://www.neue-presse.de/Hannover/Meine-Stadt/Hannover-fuerchtet-sich-vor-dem-grossen-Hochwasser, last accessed: 01.08.2019.

Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, 2013: Kommunale Hochwasserschutzplanung in Hannover, http://www.nlwkn.niedersachsen.de/download/80987/vortrag, last accessed: 01.08.2019.

Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz, 2019a: Hochwassergefahrenkarten und Hochwasserrisikokarten, https://www.umwelt.niedersachsen.de/themen/wasser/hochwasser_kuestenschutz/risikomanagement/hochwassergefahren_und_hochwasserrisikokarten/hochwasserkarten-121920.html, last accessed: 01.08.2019.

Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz, 2019b: Linkliste der Gefahren- und Risikokarten des NLWKN, https://www.umweltkarten-niedersachsen.de/Download_OE/HWRM-RL/Linkliste_der_Hochwasser_Gefahren_und_Risikokarten_Niedersachsen.pdf, last accessed: 01.08.2019.

OECD, 2016: Financial Management of Flood Risk, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264257689-en, last accessed: 06.07.2019.

Openstreetmap.org, 2019: OpenStreetMap, www.openstreetmap.org, last accessed: 01.08.2019

Region und Landeshauptstadt Hannover, 2019a: Begrüntes Hannover, https://www.hannover.de/Leben-in-der-Region-Hannover/Umwelt-Nachhaltigkeit/Naturschutz/Mehr-Natur-in-der-Stadt/Projekte-f%C3%BCr-%E2%80%9EMehr-Natur-in-der-Stadt%E2%80%9C/Begr%C3%BCntes-Hannover, last accessed: 12.08.2019

Region und Landeshauptstadt Hannover, 2019b: Die Südliche Leineaue, https://www.hannover.de/Kultur-Freizeit/Naherholung/Natur-entdecken/Die-Südliche-Leineaue, last accessed: 01.08.2019

Region und Landeshauptstadt Hannover, 2019c: Hochwasser in Hannover, https://www.hannover.de/Leben-in-der-Region-Hannover/Umwelt-Nachhaltigkeit/Wasser-Abwasser/Abwasser/Stadtentw%C3%A4sserung-Hannover/Hochwasserschutz/Hochwasser-in-Hannover, last accessed: 01.08.2019

Sachgebiet Stadterneuerung, 2018: Mein Quartier 2030 - Integriertes Entwicklungskonzept Stadtbezirk Ricklingen. Landeshauptstadt Hannover: Hannover

Statistische Berichte der Landeshauptstadt Hannover, 2019: Statistische Profile der Stadtteile und Stadtbezirke 2018. Landeshauptsadt Hannover, 168.

UFCOP, 2017: Land Use Planning for Urban Flood Risk Management. Washington, DC: World Bank.