www.czasopisma.pan.pl PAN POLSKA AKADEMIA NAUK www.journals.pan.pl

JOURNAL OF WATER AND LAND DEVELOPMENT

e-ISSN 2083-4535

Polish Academy of Sciences (PAN) Institute of Technology and Life Sciences – National Research Institute (ITP – PIB)

JOURNAL OF WATER AND LAND DEVELOPMENT
DOI: 10.24425/jwld.2021.137688
2021, No. 50 (VI–IX): 1–9

The problems of spatial planning and natural determinants of urban development – the Case of Powiśle in Warsaw

Joanna Koszewska[1), 2), 3)], Łukasz Kuzak[3)]

[1)] Sorbonne Université – Faculté des Lettres, Ecole Doctorale de la Géographie de Paris, Institut de Géographie, 191, Saint Jacques, 75005, Paris, France

[2)] Warsaw University of Technology, Faculty of Architecture, Warszawa, Poland

[3)] Warsaw University of Technology, Faculty of Geodesy and Cartography, Plac Politechniki 1, 00-661 Warszawa, Poland

RECEIVED 01.04.2020 REVIEWED 29.09.2020 ACCEPTED 14.11.2020

Abstract: This research examines the relationship between urban planning and environmental conditions. As urbanisation processes increase the density of the built-up tissue of cities, this process puts a lot of pressure on land and natural resources such as rivers and soil. This article aims to verify whether environmental risks (e.g. flooding) and land protection from them is sufficiently addressed in the examined spatial policies and strategies.

This problem can be observed in the Powiśle district of Warsaw where buildings are constructed in the proximity of the unregulated Vistula River and that is why there is the direct risk of flooding. It is done despite the lack of legally binding Master plans which would consider the natural risk.

The literature research on the Municipality-led spatial planning policies and documents was completed with qualitative interviews with key actors in this process (planners: the authors of Master plans under construction, regarding the area of Powiśle South and North). Main designers and team members were asked about the priorities of these plans as well as their dynamics (taking more than ten years to establish those plans).

An environmental analysis was conducted in the GIS mapping system of many databases. The comparison of both aspects of current development, formal urban planning and environmental protection was made in an interdisciplinary approach. The study presents an analysis of the situation for urban planning along with flood maps and other environmental conditions. The results show the lack of necessary alignment of environmental issues with the planning documentation and strategies.

Keywords: urban planning, flooding protection, urban sustainability, city transformation, urban resilience

INTRODUCTION

Recent decades have been a period of particularly rapid global climate change. This phenomenon is particularly noticeable in urban areas and there are even separate terms such as "urban ecosystem" and "city climate" [Zimny 2006]. In the era of progressing urbanisation modern cities face such problems as the urban heat island, stagnation of air caused by the build-up of aeration corridors, runoff of rainwater caused by the sealing of exposed land surfaces. Other negative aspects are degradation and devastation of land by industry and transport etc. Whereas certain cities are exposed to the growing flood risk, according to some forecasts other cities face the risk of draught conditions [Zimny 2006].

The problem of adjusting activities related to minimising the effects of climate change in urban planning and urban sustainability issues have been raised in international literature in recent years [Kookana *et al.* 2020]. Attempts have been made worldwide to mitigate the effects of rapid precipitation using appropriate design solutions on a smaller scale: individual objects, benches, specially designed flagstones, or architectural entities. On a larger scale designing climate-resilient streets and public

spaces as a part of public design activities might contribute to the improvement of climate sustainability. At the same time projects are also being developed to transform entire city fragments. These projects aim to alleviate climate catastrophes such as floods, hurricanes, and storm impacts [Kępiński 2020]. The proposed solutions range from natural disaster protection to the absorption of their consequences within the cityscape. Therefore, this shows a change in the approach to city development (e.g. water from intense rainfall of flood is not only seen as pollution to be removed as sewerage). The effects of climate change become a foreseen stage of the project, integrating ongoing weather changes in the still functioning urban areas [Kępiński 2020].

In terms of urban planning the areas at risk of negative flood impact should be characterised by having appropriately established guidelines and restrictions. Their purpose should be to enable their effective operation, including the obligatory introduction of "green and blue" infrastructure devices, or restrictions on the development of legal documents [Szulczewska 2009].

Globally, about forty percent of the human population lives within 100 km of a coastline [Walsh 2020]. Therefore, to act against damages caused by the rising flood risk, architects, urban planners and designers of various specialisations react in order to respond to the need of undertaking action plans and projects. These plans and projects aim to protect populations from flooding by constructing resilient structures and developing schemes slowing or even reversing the effects of urban floods. Such actions combine local scale effects in the global context to prepare and implement climate change resilient solutions [Kępiński 2020].

Copenhagen is the example of a model for a large European city (over 500,000 inhabitants) dealing with flood risks. In 2018 its local authorities allocated 60 million DKK (approx. 8 million EUR) to a comprehensive project with a time horizon of 20 years aimed at flood protection [Schiøler 2018]. The "Copenhagen Climate Adaptation Plan" was adopted setting out flood-fighting instruments annexed to local planning documents. Securing buildings and infrastructure in Copenhagen is necessary as it helps to control flood water in the urban scale efficiently by expanding the infrastructure network that drains and retains excess water by the use of the so-called sponge texture, permitting the infiltration of waters to the ground and underground tanks in public spaces in the heavily built-up city centre lacking green spaces.

Faaborg in Denmark has also an anti-flooding scheme, designed by Kjellander Sjöberg, it revives closed-down industrial areas by establishing a channel that regulates and diverts water away from the historical city centre [Harrouk 2019].

Hamburg in Germany is a case where the large-scale development (1.56 km^2) of the flood risk was dealt with by levelling the new built-up areas (8.5 m above the flooding zone).

In the case of densely populated cities, like Paris, retention functions can be performed by urban parks, like the Billancourt Park (designed by Agence TER) in Boulogne Billancourt near Paris. This project was a part of a larger revitalisation plan of a former industrial site which integrates the Seine River flowing nearby. The space located between the new quarters is surrounded by meadows, ponds, gravel troughs, islands, and wetlands, where its range varies depending on the weather conditions. The urban settlement, located in a hollow niche, is surrounded by walls like port docks, thanks to which part of the area always remains dry and available to residents. Another part is given to nature (allowing it to be flooded in a planned manner), where the designers' intention was to continue the river landscape of the Seine [Kępiński 2020].

Venice suffered from heavy flooding at the end of 2019, which has been repetitive for centuries. However, rising sea levels heighten the concerns about the city's urban fabric. A project by MOSE (from 2003) provides a system of storm gates to seal the city's lagoon from high tides in fifteen minutes [Walsh 2020]. (The lockdown in 2020 resulted in the purification of its canals).

There are other examples of cities outside Europe undertaking a natural risk plan and implementing strategies with methods for social change and urban regeneration. The following towns and their plans are worth mentioning: Boston (the project of the Mayor of the city with SCAPE Landscape Architecture increasing the open space along the 76 kilometres coastline), New York City – the project for Brooklyn (New York City borough of Brooklyn, Bjarke Ingels Group and Field Operations have developed a Master plan of mixed-use development and a flood-resilient park to reinstate natural habitats, elevate the waterfront resiliency, and transform the inhabitants approach to the East River) [Kępiński 2020]. Since 2019 New York City has been working on the plan of a coastal resilience project for Lower Manhattan, where half a billion dollars out of USD10 billion is to be dedicated to fortifying its terrain with grassy berms in parks and barriers. On the eastern part, the coastline is planned to be pushed out by as much as 150 meters, generating a new public space on a higher level, meeting rises in sea levels and storm surges. Jew Jersey Hoboken has an OMA designed strategy to protect from the high level of waters (elaborated after the coastal landfall of Hurricane Sandy in 2012) by combining hard infrastructure with soft landscaping, comprised of a green circuit to trap water with water pumps to support drainage.

Similar works are also underway in the West of the USA. As part of the Resilient by Design Challenge program, architects (HASSELL+) are redesigning waterfronts in the San Francisco Bay area. Inspired by the experiences of residents after the 1906 earthquake (and recurrent fires in California), they are organising temporary shelters in the open spaces of San Francisco; the project has networked parks, streams and shopping streets which will collect and distribute water during extreme weather events. The network of interconnected reservoirs, collectors and canals create everyday use places that might serve local communities as local crisis centres during disasters [Kępiński 2020].

Seoul integrates water into the fabric of the city itself by providing a man-made valley below street level for the Cheonggyecheon River (once covered by roadways and highways, renovated in 2003), capable of accommodating the floodwater of rainy seasons, and serving as a recreational public space in dry periods [Walsh 2020].

To summarise, a resilient, regenerative urban design has become a necessity for many cities and zones at risk of flooding. It should be accompanied by legal solutions, by defining the admissible type of investments and infrastructure of considered zones. It could even go beyond protection strategies, towards the goal enriching the ecosystem and the quality of life for the inhabitants of designed areas [Naboni *et al.* 2019] and the implementation of climate resilient urban design solutions. All examples mentioned above are summarised in the Table 1, listing all the cities facing flooding, types of flood and actions taken by them to deal with it.

Table 1. Examples of cities solutions for minimising flood risk

Example	Type of flood	Action taken to deal with it
Copenhagen (Denmark)	pluvial	"Copenhagen Climate Adaptation Plan", flood-fighting instruments annexed to local planning documents, infrastructure network that drains and retains excess water
Faaborg (Denmark)	pluvial, coastal	channel, which regulates and diverts away water from the historical city centre
Hamburg (Germany)	fluvial	levelling the new built-up areas in flood risk terrains (28 feet above the flooding zone)
Paris (France)	pluvial, fluvial	downtown parks as a source of retention, combining flood protection with revitalisation plans for a former industrial site
Venice (Italy)	coastal	system of storm gates to seal the city's lagoon from high tides in fifteen minutes
Boston, New York (USA)	coastal	natural risk plan and implementing strategies with methods for social change and urban regeneration, fortifying terrain with grassy berms in parks and barriers, combining hard infrastructure with soft landscaping
San Francisco (USA)	coastal	the network of interconnected reservoirs, collectors, and canals
Seoul (S. Korea)	pluvial, fluvial	man-made valley below street level for the river, capable of accommodating floodwater of rainy seasons and serving as a recreational public space in dry periods
Powiśle (Poland)	pluvial, fluvial	attempt of the climate change mitigation fulfilled insufficiently in regulatory documents, as Study of Conditions and Directions of Spatial Development and in Master Plans

Source: own elaboration.

Getting back to the Polish geographical context, based on the available data, it can be stated that in 2013 only 12% of floodplains in Poland were covered by planning documents at the level of a local spatial development plan (Master plan – "Miejscowy plan zagospodarowania przestrzennego") [NIK 2013]. Only 30% of the surface of Poland is covered by master plans [NIK 2016].

In the areas where the plans were legally binding, in most cases, no prohibitions or restrictions on the possibility of building in flood risk areas were introduced [NIK 2013; 2016]. Similarly, in the Study of Conditions and Directions of Spatial Development of communes (Pol. Studium uwarunkowań i kierunków zagospodarowania przestrzennego), spatial development directions regarding limitation of floodplain development are not usually specified. According to calculations conducted by the authors during the research on spatial data in Warsaw in 2020, currently, it is about 25% of the floodplains within the scope of legally binding plans. It can be said that there is some improvement, but it is still an insufficient result.

That is why this article aims to verify whether current environmental conditions, with an emphasis on the problem of flooding, are included in spatial development strategies and policies of different levels and types. The single case study of a district at risk of flooding was established for this query.

Warsaw is the subject of the analysis, precisely one of its districts – Powiśle, and has been chosen for the following study as one of the most dynamically transforming areas since the 19th century. It is a part of Warsaw with an area of 1.2 km^2, from the south bordering with Solec, from the north with the Old Town, from the east with the Vistula River and from the west with Śródmieście North and South. In 2019, Warsaw authorities adopted the Strategy of Adaptation to Climate Change for the Capital City of Warsaw to 2030 with a perspective 2050 Municipal adaptation plan [Kassenberg *et al.* 2019]. It attempts to mitigate development policies to climate change. The document mentions, among others, climate related dangers, the risk of flooding in Warsaw, which relates to 25% of the capital's area. The authors suggest improving green and blue infrastructure to retain water. They also mention the fact that such a policy should be integrated into other planning documents as a solution to present problems. Currently, since this program has no legal impact on planning documents, it can only be treated as an optional reference for policymaking.

The other important document is Announcement 01/2020 of the interdisciplinary Advisory Team on the climate crisis with the President of the Polish Academy of Sciences about climate change and water management in Poland. The announcement indicates the need to take different types of action due to the increased risk of torrential precipitation and floods, i.e. by increasing retention. At the same time, it signals the need to prevent drought that increasingly plagues the city, by introducing an appropriate network of green infrastructure [Komunikat … 2020].

The result of the following analysis is expected to confirm the initial hypothesis regarding little consideration for environmental conditions and determinants of the urban densification in the current spatial development process of the examined area. The formulation of ways to improve consideration of environmental problems in the analysed process might be the subject of further studies.

MATERIALS AND METHODS

Geo-spatial data and map information on environmental conditions (soil-agricultural maps), geological (geological maps), type of development (BDOT10k) and spatial development problems (documents and planning studies) [GUGiK 2015; 2019; PIG 2006; UM 2018] have been used to conduct the following analysis. The literature review of the subject and qualitative half-open interviews with key authors of Master plans for the Powiśle area – completing the cartographic study with insight comments of key actors were realised to verify the research hypothesis elaborated on the basis of the initial query of the spatial data. The mentioned above data, query of the literature sources, spatial analysis in the GIS system, field visits and interviews with key actors (officials, experts) of the examined processes have all been applied to conduct the presented research.

RESULTS AND DISCUSSION

Based on the analysis of the literature on the flood risk in Warsaw, some dependencies can be observed. "In the 15th century there were six floods, of which the largest were witnessed in the following years: 1475, 1495, the 16th century: 1564, 1570, 1593, the 17th century: 1605, 1635, 1647, 1667, 1671, the 18th century: 1724, 1729, 1736, 1751, 1774, 1775, 1782, 1788, the 19th century: 1808, 1812, 1813, 1814, 1830, 1837, 1839, 1840, 1844, 1845, 1855, 1860, 1880, 1884, 1887 (Fig. 1), the 20th century: 1903, 1906, 1909, 1911, 1916, 1917, 1919, 1923, 1924, 1925, 1929, 1931, 1934, 1939, 1941, 1945, 1947, 1948, 1953, 1960, 1962, 1997, the 21st century: 2010 (Photo 1)" [Świątek, Chwiszczuk 2012]. This listing could indicate that there has been an increase in the frequency of flood phenomena since the nineteenth century, with a peak in the twentieth century. This means that in the face of the increased risk, an integrated, holistic approach to this problem is important.

The increased threat is also confirmed by the wider analysis of the Vistula riverbed. The risk of flooding on the Vistula also continues to increase due to irrational economic human activity in the upper section of its basin. It mainly relates to the excessive regulation of river channels by cutting natural bends, the use of stone lining of the channels as well as changes in land use, mainly road development, including asphalt. The shortening of the course and narrowing of the riverbeds caused a rapid deepening of a riverbed. This resulted in a decrease of natural retention and an increase of the intensity of surface runoff and the speed of flood surge [Baścik, Degórska (eds.) 2015].

This situation is also associated with changes in the course of the riverbed within Powiśle (Fig. 2). Observing the borders of the riverbed from 1825 and 1841 the possibility of quite a large change within a short time is visible, resulting in flooding of an important part of the surrounding (waterside) area. In the 20th and 21st centuries, a significant part of the banks were bolstered by levees. The Vistula boulevards on the embankments were also developed and the riverbed was regulated. This means that significant changes in its course should not be expected soon, but the potential for floods should not be underestimated.

Moreover, based on the following data, it can be indicated that Powiśle is located much lower than the rest of the city (Fig. 3). A slight difference in the elevation of Powiśle and the Vistula River level as well as the lack of embankments increases the risk of pluvial and fluvial floods. This phenomenon is related to the high waves on the Vistula in early spring and high rainfall recorded in the summer – in June and July (Fig. 4).

The area of Powiśle is located to a large extent on sandy land, which is not a limitation on the development possibilities [Chmiel 2013]. However, a large area in the southern and central parts of the district is also located on silts (light fluvisols), which are described as "useful for buildings with restrictions" (Fig. 5).

Fig. 1. Flood in Warsaw in 1887. Painting "Sandblasters" by Aleksander Gierymski; source: MNW [undated]

Photo 1. Flooded boulevards in Warsaw in May 2010; source: https://commons.wikimedia.org/wiki/File:Warsaw_Vistula_river_20100521.jpg

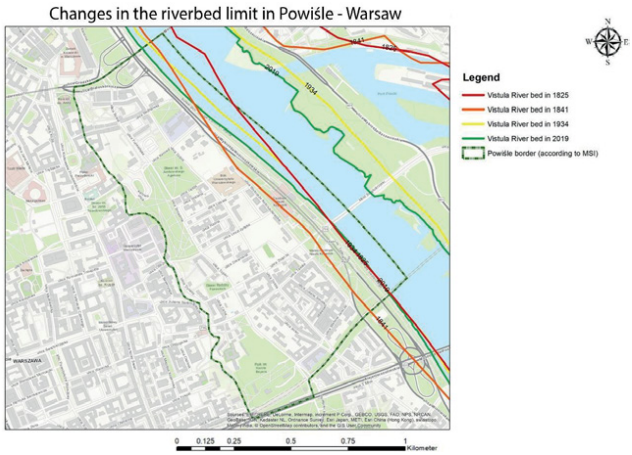

Fig. 2. Variability of the Vistula riverbed within Powiśle; source: own elaboration based on obtained spatial data [UM undated b]

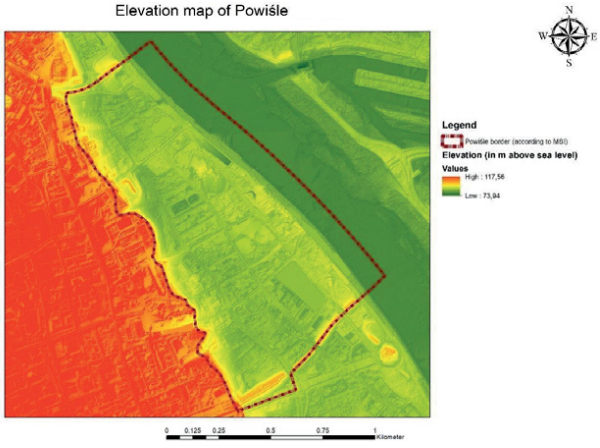

Fig. 3. Elevation map of Powiśle; source: own elaboration based on obtained digital terrain model [GUGiK 2019]

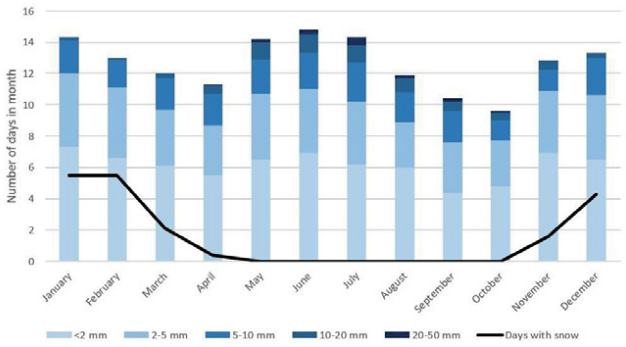

Fig. 4. Yearly rainfall precipitation data of Powiśle; source: own elaboration based on https://www.meteoblue.com weather forecasts

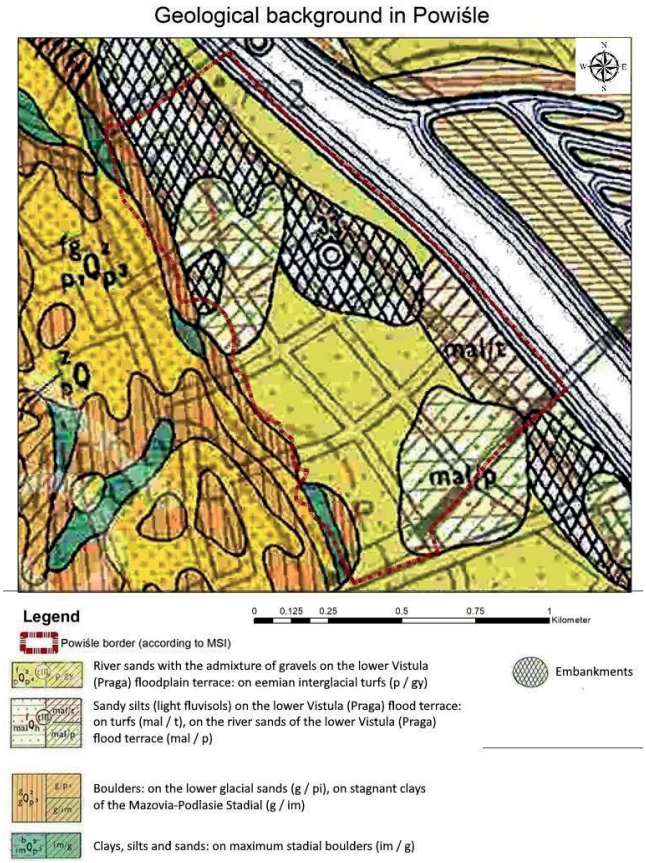

Fig. 5. Map of the geological background in Powiśle; source: own elaboration based on detailed geological map [PIG 2006]

However, these are lands much more useful for agriculture or greening. Meanwhile, only some of them are intended in this way and used for this purpose (Kazimierzowski Park, Kahl Square, Daughters of Charity of Saint Vincent de Paul Monastery Garden). These areas are also developed with buildings, both residential and public.

The restrictions on development options result from limitations of the bearing capacity of the ground [Chmiel 2013]. In many cases, the implementation of a construction investment should then involve the need to secure the ground's stability.

Based on the data from the Polish Geological Institute [PIG 2006], in Powiśle the first aquifer is located shallow in the ground. For the entire district, this depth varies from 2 to 5 m. This fact should be considered when conducting any major construction investments that could involve waterlogging of the ground.

These conditions have been included in the Study of Conditions and Directions of Spatial Development of the Capital City of Warsaw [UM 2018] by the designation of two types of areas:

- the areas with a particular risk of flooding, which is subject to the prohibitions set out in the Water Law [Ustawa … 2017] (the narrow strip of boulevards) – type 1,
- the areas at risk of flooding if flood waters overflow through the crown of the flood embankment or in case of damaging it (most of Powiśle area) – type 2.

Almost 30% of the Warsaw area is located in areas at risk of flooding in the event of flood waters overflowing through the crown of the flood embankment or its destruction or breaching (type 2 above-mentioned), including a significant part of Powiśle.

This can be confirmed by analysing the areas exposed to floods visible below (Fig. 6), originated from the flood risk maps developed by KZGW for Warsaw in 2015. They were compared with the data included in the Study of Conditions and Directions of Spatial Development of the Capital City of Warsaw [UM 2018].

It is worth mentioning that a new Study for Warsaw is currently being developed (starting from May 2018) [Uchwała… 2018]. According to the assumption, the goal is to make Warsaw more friendly to residents and resistant to climate change, including green infrastructure solutions and minimising flood risk.

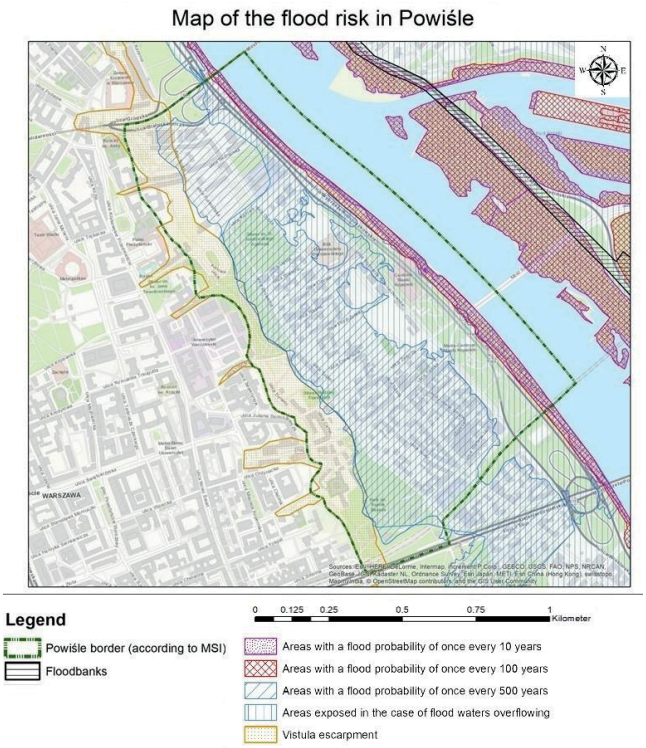

Fig. 6. Map of flood risk in Powiśle; source: own elaboration based on obtained spatial data [KZGW undated; UM 2018]

The flooding aspects should be considered everywhere, and detailed, multifaceted, balanced strategies should be created on their basis [Solarek *et al.* 2016]. Flood planning in Warsaw is based on the "Flood Risk Management Plan for the Vistula River Basin" developed by National Board of Water Management (Pol. KZGW – Krajowy Zarząd Gospodarki Wodnej) and containing

general guidelines for the entire river basin. Meanwhile, local documents focusing on Warsaw are limited to hardly accessible documents from 1999, 2002 and 2004 developed by the Regional Board of Water Management (Pol. RGZW – Regionalny Zarząd Gospodarki Wodnej) in Warsaw (including the "Comprehensive Regional Flood Protection Program in the Central Vistula basin in the RZGW in Warsaw" [RZGW 1999]). There is also a lack of adequate green infrastructure networks, partly reducing the risk of flooding and the negative effects of climate change. Apart from the boulevards, no large investments are aimed at sustainable water management. In the Powiśle district, only an area of 1.5 ha out of 120 ha is covered by the currently binding Master plans – it represents 1.25% of the Powiśle surface. In other areas, there are two plans under development – for Powiśle North and Powiśle South. For many reasons, they have not yet been adopted despite the planning process that has been going on for about ten years. The main of these reasons is the fact that Powiśle is in a large part of a flood plain where buildings cannot be built [Bartoszewicz 2012]. Moreover, the spatial plans generate conflicts of irreconcilable individual and group interests, transportation and environmental problems and encounter issues related to unregulated ownership of plots. This also lengthens planning procedures, which is unfortunately typical for Warsaw and should be changed in the nearest future.

The rules and regulations have become more stringent because of the Water Law Act of January 5, 2011 [Ustawa … 2011], which was a result of the implementation of the European Parliament Floods Directive [Directive 2007/60/EC]. RZGW had a duty to develop detailed flood hazard and risk maps as well as flood risk management plans. The Floods Directive formulates the obligation of updating all planning documents every six years. Based on these regulations, RZGW refused to agree to a draft plan for the Powiśle South submitted by the Warsaw authorities (Fig. 7).

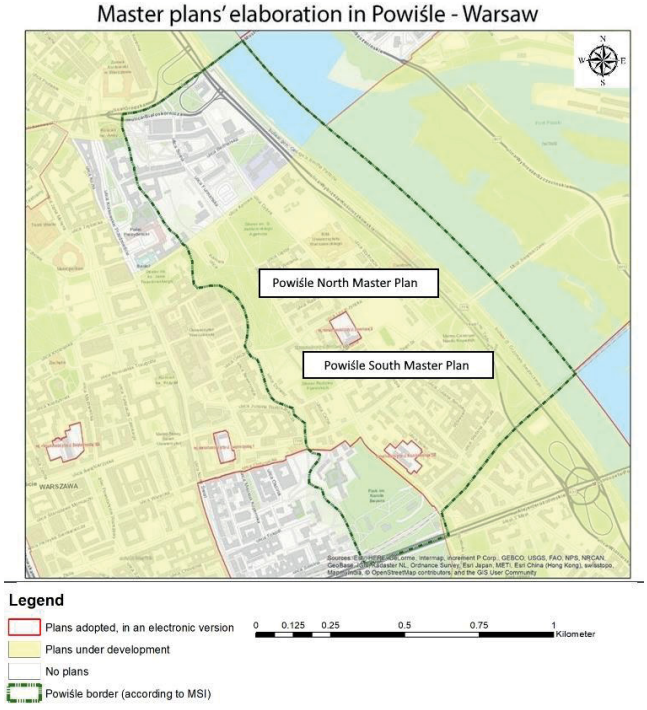

Fig. 7. Map of coverage with local Master Plans in Powiśle in 2019; source: own elaboration based on obtained spatial data [UM undated a]

In addition, the new Water Law of July 20, 2017, introduced mandatory arrangements with the Polish Waters (Pol. Państwowe Gospodarstwo Wodne Wody Polskie) regarding the scope of development directions for estates located in areas at particular risk of flooding – where the probability of flooding is once every 100 years. However, there is still a lack of more detailed guidelines for areas of potential danger – probability once every 500 years and in the event of flood overflow through the crown of the flood embankment.

However, this situation is somewhat comfortable from the point of view of potential investors. Unlike cities and voivodships which have developed special flood protection studies and programs; in the face of an existing flooding threat in Powiśle, no unequivocal instruments are protecting this area by limiting constructions. Not all housing estates are equipped with e.g. drainage systems [Wagner *et al.* 2013], there are also no relevant restrictions and orders in planning documents (which, in the absence of Master plans, are temporarily based on quite numerous WZ – decisions and building permits, Pol. decyzje o warunkach zabudowy, which are particular plot used planning decisions not necessarily coherent with other decisions in the neighbourhood and not required by law to be consistent with other planning documents of different levels).

The map illustrating WZ decisions elaborated for the Powiśle district shows that no such decisions have been issued for areas threatened by the 10- and 100-year floods. They have, indeed, been issued for the areas threatened by the 500-year floods, i.e. as a result of restructuring post-industrial areas. It is a positive phenomenon, compatible with the sustainable development principle. But it will be better to combine this with available planning instruments, e.g. municipal revitalisation program or local revitalisation plan (a special type of local spatial development plan introduced in 2015 by a national law (Act of Revitalisation, Art. 15, paragraph 1, point 13) [Ustawa … 2015]. In fact, the Warsaw Revitalisation Program (document of local strategy) covers only three districts of Warsaw (Praga Północ, Praga Południe, Targówek) and there is no single binding Local Revitalisation Plan (a special type of Master Plan) in the whole city.

As a result, there is no uniform vision for the development of post-industrial space in Powiśle and no real control over a possible threat (Fig. 8).

In addition to the lack of planning documents, there is also a problem connected with the lack of standards for conducting planning studies in the field of water management and flood protection. Thus, flood risk maps and integrated economic assumptions are often not taken into account or the adoption of plans is postponed significantly [NIK 2013].

So, it is visible that from year to year the threat concerning the Southern Powiśle covered with compact buildings [Dudek-Mańkowska *et al.* 2018] is increasing. The Water Law Act introduces a ban on constructing new and extending existing buildings, digging wells and other works that may weaken the stability of embankments at a distance of less than 50 m from the foot of the embankment. However, there are no embankments in this area, which means that no restrictions resulting from the distance from the foot of the embankment can be introduced (Water Law, Art. 176, paragraph 1) [Ustawa … 2017]. There is a lack of coordination of this situation, and due to the high historical value of these areas, more radical actions should be taken, e.g. in the form of developing drainage infrastructure for built-up areas and small retention reservoirs nearby.

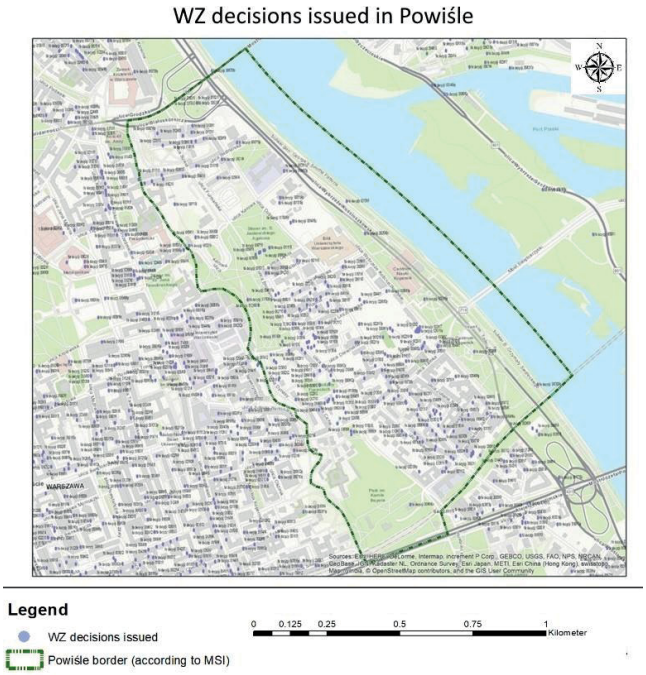

Fig. 8. Decisions and building permits (WZ decisions) issued in Powiśle until 2019; source: own elaboration based on obtained spatial data [UM undated c]

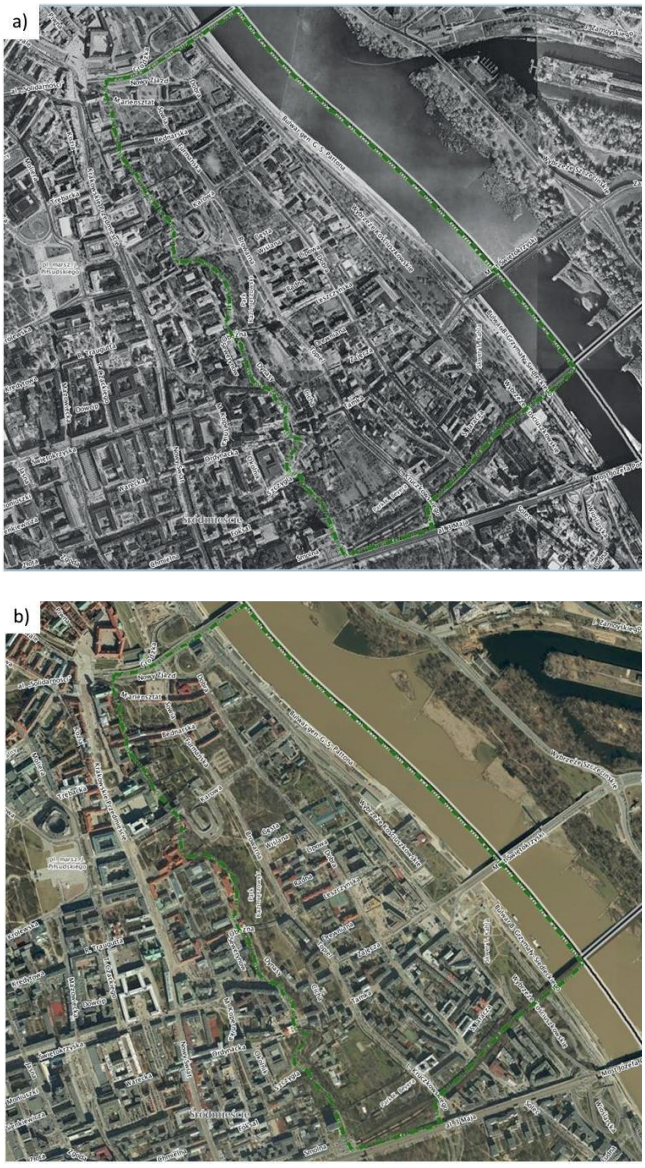

Fig. 9. Aerial photographies of Powiśle taken in: a) 1990 shows non-built riverbanks, b) 2019 shows concrete-built riverbanks; source: UM [undated d]

Based on an analysis of aerial photographs of Powiśle from 1990 and 2019 (Fig. 9), the tendency to develop river boulevards can be observed. While in 1990 many post-industrial plots remain non transformed into different functions, in 2019 many post-industrial plots are transformed into different functions and densified. These boulevards are ultimately intended to have a recreational function for residents, but also to be one of the dams for potential flood waters. In addition, buildings located on the boulevards are equipped with special systems of anchors allowing the pavilions built there to float on water, in the case of a significant increase in the level of water in the Vistula. However, it should be remembered that the boulevards are not equivalent to levees and, as a result, there are no restrictions on a building development at a distance of 50 m from them. It can still be concluded from an analysis of the available flood risk maps that despite the development of the boulevards the areas of Powiśle are endangered and the current solutions are not sufficient to protect this area from flooding and its consequences.

In addition, the photographs presented below illustrate the degree of transformation and development of the Powiśle area. The transformation and revitalisation of industrial areas occurring in the 1990s, include the Powiśle Power Plant, which was transformed for service, office, and residential constructions purposes [Maciejewska, Turek 2019]. It should also be remembered that the new buildings are also still being built in areas at risk of flooding, being implemented without major restrictions based on the aforementioned WZ decisions on building conditions (Pol. decyzje o warunkach zabudowy).

CONCLUSIONS

In the context of a rapidly changing climate, the risk of flooding is increasing globally and locally, as in the case of Powiśle. In particular, in the research within the discipline of spatial planning and in the practice of the implementation of urban construction projects, these aspects should be taken into account. Solutions such as the requirement for implementation of the absorbent surfaces in the flooding areas along with other design responses to the problem of combating the man-driven cause of climate change should be applied. The hygienic quality of life in Warsaw is at risk (in 2019 and 2020 by break downs of the local sewage treatment plant Czajka, affecting the water purity in the Vistula River).

Progressing urbanisation in the city should include a detailed analysis of environmental conditions, such as geological background, occurrence, and condition of groundwater purity. However, it is also necessary to take into account aspects related to the city's climate and adapting the area to the needs of minimising negative trends. This may take the form of technical infrastructure devices or green and blue infrastructure.

However, it is ultimately necessary to create a comprehensive spatial planning system that takes into account all the mentioned above problems. This system should be based on plans which

include all necessary components of sustainable development and flood restrictions, constituting an alternative to mass development of non-coordinated particular decisions, frequently issued by WZ (Pol. decyzja o warunkach zabudowy). It is also worth mentioning that if we are dealing with the post-industrial area, the solutions introduced by the Act of Revitalisation (municipal revitalisation program, local revitalisation plan) should be used.

The result of insufficient coordination of environmental and revitalisation policies is particularly visible in the case of Powiśle in Warsaw, where aspects of climate change and flooding appear not to be taken into consideration and new buildings are constantly being located on the floodplains. Despite the flooding threats to the environment and a lack of agreement on the new construction development based on short decisions (WZ) from the Regional Board of Water Management (Pol. Regionalny Zarząd Gospodarki Wodnej – RZGW), uncoordinated development is continuing. A spatial development Master Plan (Miejscowy plan zagospodarowania przestrzennego – MPZP) – which is a complex tool for urban planning might be a better instrument than particular urban decisions (WZ) for development in Powiśle. The complimentary elaborated planning documents such as Master Plans coherent with strategies on a national and regional level would facilitate coordinated water-sewage and rainwater management for the benefit of an anti-flooding system for Warsaw.

The Resolution of a new Study for Warsaw [Uchwała… 2018] together with the adopted Strategy for Adaptation to Climate Change [Kassenberg *et al.* 2019], create a new procedural opportunity for the future improvement in the matter of more effective water and flood spatial management. A particularly important element of an effective planning system might be also a preparation of comprehensive local Master Plans, enriched with precise flooding regulations. In addition, as presented in exemplary cities policies, which have resulted in the mitigation of the risk of flooding significantly, it seem legitimate for Warsaw authorities to plan the network of a green and blue infrastructure (e.g. in post-industrial areas), that would increase rainwater infiltration and retention as well as limit climate anomalies.

REFERENCES

Bartoszewicz D. 2012. Zobacz, gdzie wyleje Wisła. Tu nie wolno budować [See where Vistula will pour out. You can't build here]. Gazeta Wyborcza. Nr 26.01.2012.

Baścik M., Degórska B. (ed.) 2015. Środowisko przyrodnicze Krakowa. Zasoby – ochrona – kształtowanie [The natural environment of Krakow. Resources – protection – shaping]. Kraków. Uniwersytet Jagielloński pp. 290.

Chmiel J. 2013. Analizy przestrzenne i modelowanie. W: Informacja przestrzenna dla samorządów terytorialnych [Spatial analysis and modelling. In: Spatial information for local governments]. Ed. S. Białousz. Warszawa. Oficyna Wydawnicza Politechniki Warszawskiej p. 250–254.

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks [online]. [Access 9.03.2021]. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007L0060

Dudek-Mańkowska S., Grochowski M., Porczek M. 2018. Ewolucja funkcjonalno-przestrzenna Powiśla [Functional and spatial evolution of Powiśle] [online]. [Poster]. [Access 9.03.2021]. Available at: https://www.researchgate.net/publication/325674933. DOI 10.13140/RG.2.2.35816.98565.

GUGIK 2015. Baza danych obiektów topograficznych 10k [Database of topographic objects 10k] [online]. Warszawa. Główny Urząd Geodezji i Kartografii. [Access 9.03.2021]. Available at: https://mapy.geoportal.gov.pl/

GUGIK 2019. Numeryczny model terenu obszaru Powiśla [Digital terrain model of the Powiśle district] [online]. Warszawa. Główny Urząd Geodezji i Kartografii. [Access 9.03.2021]. Available at: https://mapy.geoportal.gov.pl/

Harrouk C. 2019. Kjellander Sjöberg Wins Competition to Climate Proof the Coastal Town of Faaborg in Denmark [online]. [Access 17.02.2021]. Available at: https://www.archdaily.com/931112/kjellander-sjoberg-wins-competition-to-climate-proof-the-coastal-town-of-faaborg-in-denmark

Kassenberg A., Szymalski W., Drogosz L., Bugaj M., Jakubczak I. 2019. Strategia adaptacji do zmian klimatu dla m. st. Warszawy do roku 2030 z perspektywą do roku 2050. Miejski plan adaptacji [Strategy of adaptation to climate change for the Capital City of Warsaw to 2030 with a perspective 2050 Municipal adaptation plan] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: https://zielona.um.warszawa.pl/sites/all/files/strategia_2030.pdf

Kępiński K. 2020. Woda [Water] [online]. Architektura i Biznes. [Access 17.02.2021]. Available at: https://www.architekturai-biznes.pl/woda,3123.html?fbclid=IwAR2hi1ZDgsSY9wP_uV-J6ZriLFJAVU7vt8pecII6uWBnkLQ6YMoElERrPJU

Komunikat 01/2020 interdyscyplinarnego Zespołu doradczego do spraw kryzysu klimatycznego przy Prezesie PAN na temat zmiany klimatu i gospodarki wodnej w Polsce [Announcement 01/2020 of the interdisciplinary Advisory Team on the climate crisis at the President of the Polish Academy of Sciences about climate change and water management in Poland] [online]. Warszawa. Polska Akademia Nauk. [Access 9.03.2021]. Available at: https://informacje.pan.pl/images/2020/20200612_komunikat_zespolu_doradcow_PAN_1.pdf

Kookana R., Drechsel P., Jamwal P., Vanderzalm J. 2020. Urbanisation and emerging economies: Issues and potential solutions for water and food security. Science of The Total Environment. Vol. 732, 139057. DOI 10.1016/j.scitotenv.2020.139057.

KZGW undated. Mapy zagrożenia powodziowego i mapy ryzyka powodziowego [Flood hazard maps and flood risk maps] [online]. Warszawa. Krajowy Zarząd Gospodarki Wodnej. [Access 9.03.2021]. Available at: http://mapy.isok.gov.pl

Maciejewska A., Turek A. 2019. Rewitalizacja terenów poprzemysłowych [Revitalisation of post-industrial areas]. Warszawa. Wydawnictwo Naukowe PWN pp. 150.

MNW undated. Piaskarze. Gierymski, Aleksander (1850–1901) – malarz [Sandblasters. Gierymski, Aleksander (1850–1901) – painter] [online]. Warszawa. Cyfrowe Muzeum Narodowe. [Access 9.03.2021]. Available at: https://cyfrowe.mnw.art.pl/pl/katalog/511246

Naboni E., Natanian J., Brizzi G., Florio P., Chokhachian A., Galanos T., Rastogi P. 2019. A digital workflow to quantify regenerative urban design in the context of a changing climate. Renewable and Sustainable Energy Reviews. Vol. 113, 109255. DOI 10.1016/j.rser.2019.109255.

NIK 2013. Informacja o wynikach kontroli. Planowanie i realizacja inwestycji na terenach zagrożonych powodzią [Information on the inspection results. Planning and implementation of investments in areas at risk of flooding]. Warszawa. Najwyższa Izba Kontroli pp. 73.

NIK 2016. System gospodarowania przestrzenią gminy jako dobrem publicznym [System of the spatial governance of the commune as a public good]. Warszawa. Najwyższa Izba Kontroli pp. 30.

PIG 2006. Szczegółowa mapa geologiczna Polski [Detailed geological map of Poland] [online]. Warszawa. Państwowy Instytut Geologiczny. [Access 9.03.2021]. Available at: http://baza.pgi.gov.pl/resources.html?type=map50&id=524

RZGW 1999. Kompleksowy, regionalny program ochrony przeciwpowodziowej dorzecza środkowej Wisły na terenie RZGW w Warszawie. Ocena stanu zagrożenia powodziowego w obszarze dorzecza środkowej Wisły [Comprehensive Regional Flood Protection Program in the Central Vistula basin in the RZGW in Warsaw. Flood risk assessment in the middle Vistula River basin]. Warszawa. Regionalny Zarząd Gospodarki Wodnej pp. 120.

Schiøler T. 2018. København afsætter 60 millioner til sikring mod oversvømmelser [Copenhagen allocates 60 million to protect against floods] [online]. [Access 12.02.2021]. Available at: https://www.tv2lorry.dk/kobenhavn/kobenhavn-afsaetter-60-millioner-til-sikring-mod-oversvommelser

Solarek K., Ryńska E.D., Mirecka M. 2016. Urbanistyka i architektura w zintegrowanym gospodarowaniu wodami [Urban planning and architecture in integrated water management]. Warszawa. Oficyna Wydawnicza Politechniki Warszawskiej pp. 122.

Szulczewska B. 2009. Plan zielonej infrastruktury: nowa moda czy rzeczywista potrzeba? [Green Infrastructure Plan: a new fashion or real need?]. Studia KPZK PAN. T. 123 p. 89–96.

Świątek T., Chwiszczuk R. 2012. Królowa Wisła [Queen Vistula]. Warszawa. Fundacja CULTUS pp. 157.

Uchwała nr LXVII/1854/2018 Rady m. st. Warszawy w sprawie przystąpienia do sporządzania Studium uwarunkowań i kierunków zagospodarowania przestrzennego m.st. Warszawy [Resolution No. LXVII/1854/2018 of the Council of the Capital City of Warsaw on commencing the preparation of the Study of Conditions and Directions of Spatial Development for the Capital City of Warsaw].

UM 2018. Studium uwarunkowań i kierunków zagospodarowania przestrzennego m.st. Warszawy [Studium uwarunkowań i kierunków zagospodarowania przestrzennego m.st. Warszawy] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: http://www.architektura.um.warszawa.pl/studium

UM undated a. Plany zagospodarowania [Master Plans] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: https://mapa.um.warszawa.pl/

UM undated. Wały Wisły [Vistula riverbeds] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: https://mapa.um.warszawa.pl/

UM undated. Warszawa dzisiaj [Warsaw today] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: https://mapa.um.warszawa.pl/

UM undated. Warszawa historyczna [Historical Warsaw] [online]. Warszawa. Stołeczne Miasto Warszawa. [Access 9.03.2021]. Available at: https://mapa.um.warszawa.pl/

Ustawa z dnia 5 stycznia 2011 r. o zmianie ustawy – Prawo wodne oraz niektórych innych ustaw [The Act of 5 January 2011 amending the Act – Water Law and certain other acts], consolidated text. Dz.U. 2011 nr 32 poz. 159

Ustawa z dnia 9 października 2015 r. o rewitalizacji. Tekst jednolity [Act of Revitalisation 9 October 2015], consolidated text. Dz.U. 2020 poz. 802.

Ustawa z dnia 20 lipca 2017 r. – Prawo wodne. Tekst jednolity [Act of 20 July 2017 – Water Law], consolidated text. Dz. U. 2020 pos. 310.

Wagner I., Krauze K., Zalewski M. 2013. Błękitne aspekty zielonej infrastruktury [Blue aspects of green infrastructure]. Zrównoważony Rozwój – Zastosowania. No 4 p. 145–155.

Walsh N.P. 2020. How cities are using architecture to combat flooding [online]. [Access 12.02.2020]. Available at: https://www.archdaily.com/931720/how-cities-are-using-architecture-to-combat-flooding

Zimny H. 2006. Ekologia miasta [Ecology of the city]. Kraków. Agencja Reklamowo-Wydawnicza Arkadiusz Grzegorczyk pp. 233.