

Rainwater management in urban areas in Poland and Hungary

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Abstract. The issue of rainwater in urban areas has become more topical due to climate change. In many countries around the world, actions are being taken to minimise the negative consequences of extreme weather phenomena, including short-term, heavy precipitation. The work focuses on the analysis and evaluation of activities related to rainwater management in urban areas in Poland and Hungary. The analysis covers environmental, socio-economic and legal conditions, as well as selected technical solutions related to rainwater management. National- and local-authority measures relating to urban rainwater are discussed and assessed. Legislative solutions in the field of research issues are indicated and compared. The analysis shows differences in approach to elements of rainwater management between the two countries. Attention is given to positive changes in the approaches that national and local authorities and the public take to rainwater. It is indicated that the main barriers to a comprehensive sustainable rainwater management solution in urban areas in Hungary and Poland are financial.

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1. Introduction

For more than a century the share of urban population in the total population has been steadily increasing. Conservative forecasts indicate that, by 2050, approximately 70% of the world's population will live in cities (Ritchle & Roser, 2018). Growing urban populations are accompanied by an increase in the area that cities occupy or by greater density of buildings. This is placing increasing pressure on the natural environment. It is also requiring an expansion of urban infrastructure, which in some cases is somewhat constrained by technical limitations. This applies especially to water supply and sewerage infrastructure (Dziopak, 2018; Rodriguez-Sinobas et al., 2018).

The expansion of cities and the densification of built-up areas bring with them an increase in sealed area, which changes the dynamics and volume of surface runoff and of groundwater recharge (Bruni et al., 2015; Starzec et al., 2020; Rosenberger et al., 2021). In some regions, this results in falling water tables, which has implications for urban vegetation (mainly trees). For this reason, in many cities, new tree plantings require additional care – especially watering – which significantly increases the cost of such projects. Despite this, it is still in common practice that biologically active areas are being replaced with non-porous surfaces (Chan et al., 2018). According to the Hungarian Government Decree of July 15, 2021, on the content of and procedure for developing and adopting town plans, which also relates to certain special legal institutions for town planning, such plans for newly built areas must allow that “the biological activity value of the administrative area of the municipality must not decrease compared to the biological activity

value before the reclassification”. This value must be confirmed with a calculation in which specific given values for land-use categories (e.g., industrial zone, sports area, forest, city centres) and for surface qualities for at least ten vegetation types (e.g., treelined road, water surface) are applied to evaluate differences in the value of biological activity before and after the modification of individual land-use zones. The values fall in the range 0–9 and are given in score/ha.

Currently, there is a rising trend in surface runoff in relation to infiltration, evaporation and surface retention (Marszelewski & Piasecki, 2021). This results in a constantly growing amount of rainwater and snowmelt (hereinafter, for convenience, “rainwater”) being drained from the urban catchment area through the rainwater drainage system (Fig. 1). If we also take into account the effects of climate change, which include increased frequency of extreme weather conditions (e.g., short-term and heavy rains), then the causes of increasingly frequent local flooding in urban areas become clear.

This issue of rainwater in urban areas has become increasingly important in recent years. As a result, more and more cities are noting the problem and taking actions to reduce the negative consequences of improper rainwater management. These activities also constitute part of the trend that has been observed towards the development of city policies on climate change adaptation. It should be emphasised that these urban adaptation policies differ in nature and form depending on many factors, including legal regulations, available planning tools and instruments, and financial resources (Pancewicz, 2021; Gwoździej-Mazur et al., 2022). An important aspect of climate change adaptation activities is modern infrastructure solutions to increase the resilience and attractiveness

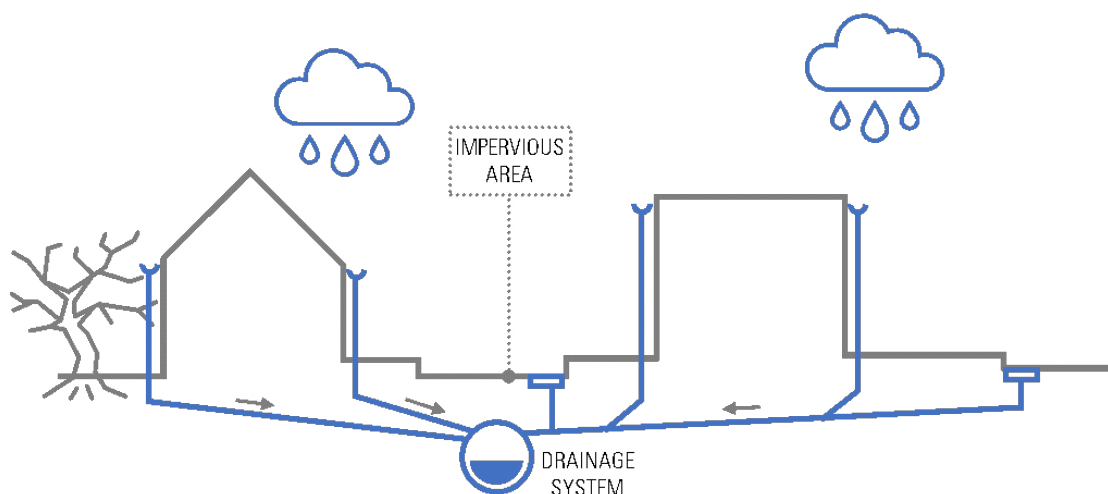


Fig. 1. Rainwater drainage system

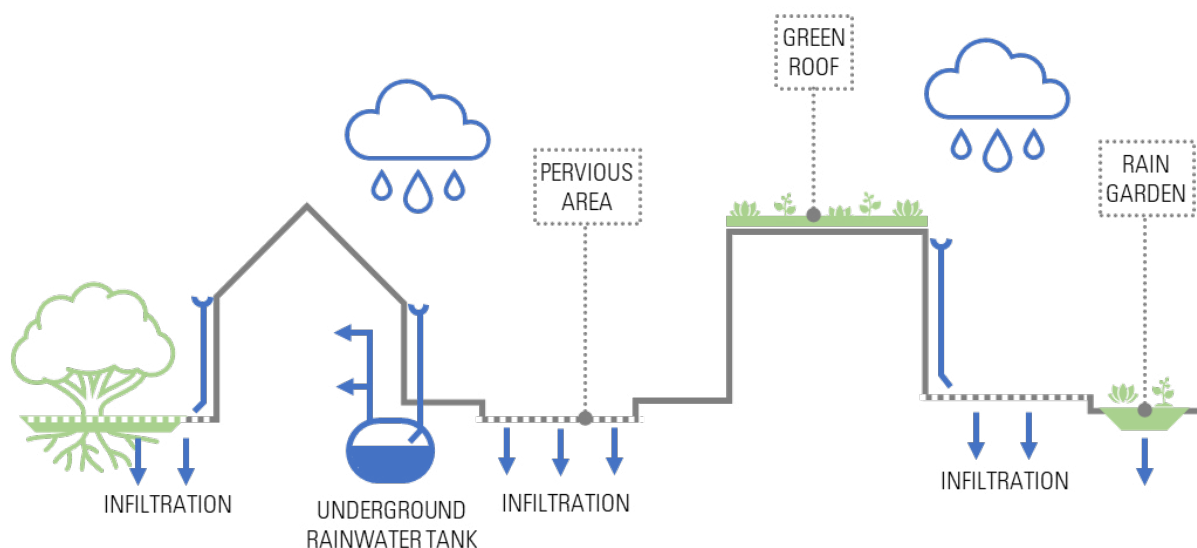


Fig. 2. Blue-green urban infrastructure

of cities. Broadly speaking, these solutions are most often referred to collectively as “blue-green urban infrastructure” (BGI) (Fig. 2). Different countries prefer different solutions related to water management in urban areas, including low impact development (LID) measures, sustainable drainage systems (SuDS), best management practices (BMPs) and water sensitive urban design (WSUD). These terms describe the same solutions, which differ mostly in origin and focus – water retention at source sites, quality improvement of runoff from roads, etc. (Fletcher et al., 2015).

There are many studies in the literature that list and describe in detail the elements that comprise BGI (Bears, 2018; Almaaitah et al., 2021; Battemarco et al., 2022). Many studies have drawn attention to the effectiveness of specific types of BGI relative to local conditions (e.g., type of ground, slope, land cover, amount of precipitation, river network, lakes, ponds) (Canales et al., 2020; Puchol-Salort et al., 2021; Suleiman, 2021; Li et al., 2022; Sánchez & Govindarajulu, 2023).

The process of broadly understood climate change adaptation appears to be widespread and inevitable. However, individual countries approach it differently. This is partly for socio-economic and political conditions, but, in essence, it is closely related to national levels of development and wealth. Highly developed countries place much greater emphasis on implementing various pro-ecological solutions related to climate change than underdeveloped and developing countries. In this context, there are interesting relationships within the European Union. Countries that acceded to the EU after 2003 are far less wealthy and have lower levels of development than countries that joined earlier. Therefore,

analyses of climate change adaptation measures being undertaken by more recent members of the EU are particularly important. Currently, the most urgent climate change adaptation issues appear to be related to water resources, and especially to urban areas. The reason for this is the additional synergy between the process of urban development (and the aforementioned range of related processes, including the sealing of land surfaces) and the intensification of extreme phenomena. As a result, urban areas inhabited by the majority of the population now require urgent intervention. Among the European countries struggling with the effects of climate change and urbanization are Poland and Hungary, where rainwater management has been based for many years on the dominance of conventional storm water drainage systems. The pressure of increased rainwater runoff on the operation of drainage systems has been demonstrated in many studies conducted in Poland (e.g. by Nowakowska et al., 2017) and Hungary (e.g. by Ronczyk et al., 2015). Therefore, there is a strong need for promoting sustainable solutions that will relieve drainage systems in these countries. For these reasons, it was decided to conduct an analysis and assessment of rainwater management in urban areas in Poland and Hungary. It should be emphasised that the literature lacks such analyses. Achieving the study objective required the formulation of the following research questions regarding the two countries:

1. Are actions taken by national and local authorities regarding rainwater in urban areas, and if so, what are they?
2. What legal solutions exist for rainwater management in urban areas?
3. Is collecting and using rainwater for use by the general public economically justified?

2. Research area

The work focuses on issues of rainwater in urban areas in Poland and Hungary (Fig. 3). The natural conditions of the two countries are largely similar to one another. Both countries have quite diversified topography and a dominant share of lowland areas. The climate of both countries is classified as temperate, transitional and warm. There are significant differences between the countries in terms of geographical size, population size, number and sizes of cities, and urbanisation coefficient values. Poland covers over 312,000 km² and is more than three times larger than Hungary. The number of Polish inhabitants is also four times higher, at approximately 38 million. The urbanisation rate is higher in Hungary and amounts to over 72%, compared to approximately 60% in Poland. Despite this fact, there are decidedly more cities in Poland than in Hungary (Poland – 979, Hungary – 328). In both countries, the capital is the largest city and is the only one exceeding a million inhabitants. Moreover, in Hungary there are eight cities with populations in the 100k–500k range and ten with populations of 50k–100k inhabitants. The remaining cities in Hungary have fewer than 50,000 inhabitants, with

over 90% of them having fewer than 25,000. Poland, on the other hand has 36 cities with a population of 100k–500k and 46 with populations of 50k–100k. Similarly to Hungary, the remaining cities in Poland are predominantly of fewer than 25,000 inhabitants.

3. Materials and methods

To achieving the study objective and answer the research questions, a comprehensive analysis of the research issues was undertaken. The analysis covered environmental, socio-economic and legal conditions, as well as selected technical solutions related to rainwater management. The basic method was logical argumentation, which was based on a critical analysis of planning documents and scientific papers. The descriptive method and the formal dogmatic method were used in the legal analysis. The legal analysis also included comparative legal remarks. The legal analysis cites relevant legal acts. To achieve the research goal, research techniques such as a literature review, description, data interpretation and case study were used.

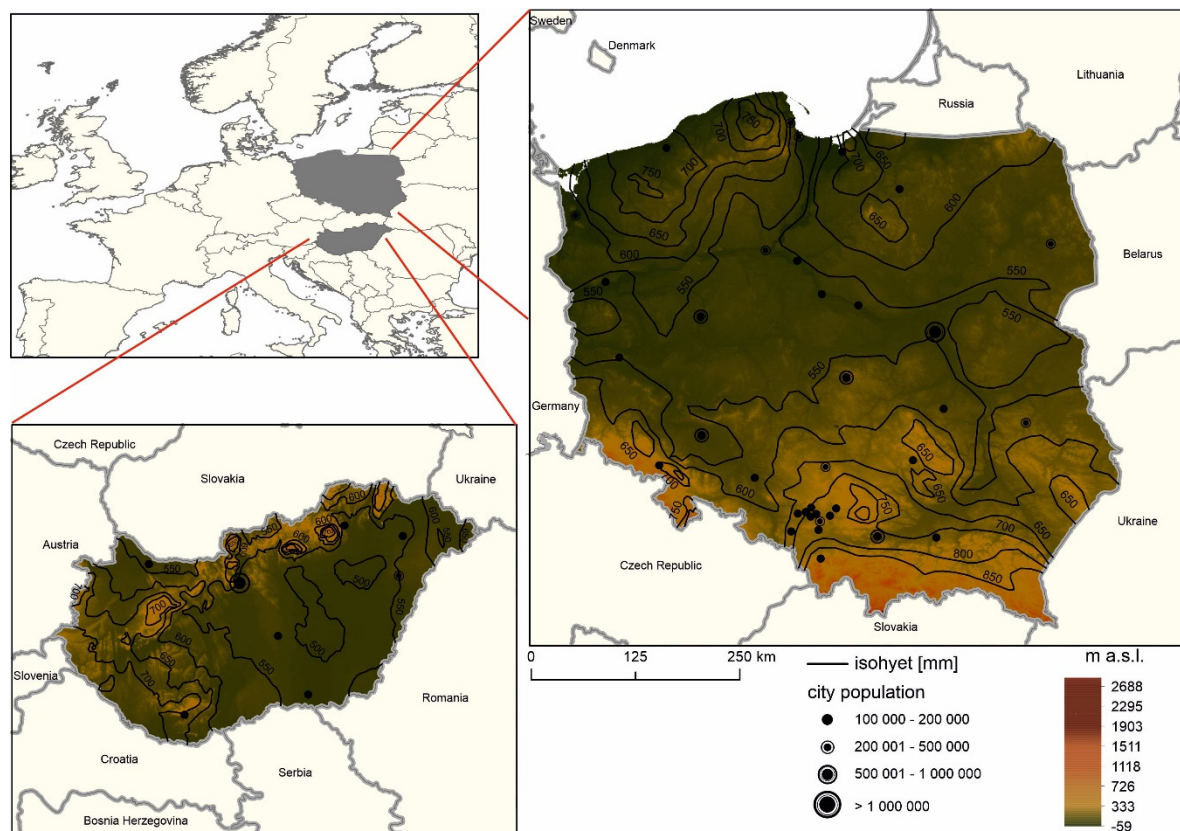


Fig. 3. Location of the largest cities in Poland against the background of selected natural conditions

4. The multi-contextual nature of rainwater issues in urban areas

4.1. Environmental context

In the model approach, natural conditions are determined by three major rainwater-related quantitative values: recharge, infiltration and runoff. The recharge associated with the occurrence of precipitation may vary in size and time of occurrence. In terms of annual sums of precipitation, there is a large convergence between the two countries. The highest sums of precipitation in each country occur in foothill and mountain areas (800–900 mm). In Poland, slightly higher annual sums of precipitation are also recorded in the northern part – the coastal zone (700–750 mm). In both countries, values are significantly lower in lowland areas, where they amount to 500–600 mm per year. Both countries also have regions with even lower rainfall of below 500 mm per year. One such area in Poland is the Greater Poland–Kuyavia Lake District, and in Hungary there is the central part of the Great Hungarian Plain. The cited values clearly indicate relatively low sums of precipitation in the two countries. However, crucially, the main problem for cities of the two countries is not the annual sum of atmospheric precipitation itself, but the fact that most precipitation is concentrated within a short period of time (short-term, intense precipitation) and that there are also long dry periods. This fact is all the more important because, in recent years, the frequency of extreme atmospheric phenomena has increased in Europe (as well as in other parts of the world). This applies to both short-term intense precipitation (Schmocker-Fackel & Naef, 2010; Wałęga et al., 2016) and prolonged periods without rain (Chmielowski et al., 2017; Młyński et al., 2019). The increasing frequency of extreme precipitation events will, in the coming years, contribute to an increased number of flash floods in cities.

The other two factors mentioned, i.e. infiltration and runoff, are closely related. Both are also the result of natural conditions related to, respectively, soil type and topography. In the case of Poland and Hungary, most cities are in areas with relatively little-diversified terrain (most often in lowland or upland areas). However, many cities have locally greater differences in relief altitudes, which causes accelerated water outflow. However, the infiltration factor is usually more important in the local water cycle of the urban areas of both countries. The issue of rainwater infiltration has for many years been

marginalised in many countries and not taken into account at the planning and development stage of cities. There was a belief that rainwater should be drained from the development area as quickly as possible through an extensive rainwater drainage system. Such solutions were likewise put into practice in Poland and Hungary. As a result, for many years, the development of urban areas was accompanied by a sharp increase in sealed areas. Currently, despite greater ecological awareness of the importance of water in the functioning of the urban ecosystem, investments are being made that are further sealing surfaces in cities. In many cases, for economic reasons, development is intensifying sharply. The best example of this is new housing estates. In Poland, most apartments were built in the 1970s and 1980s. During this period, large-panel system (prefabricated concrete) housing estates were mainly built. These apartment blocks are now of a low standard. However, housing estates built in that period have one definite advantage over those currently being built. This is the area devoted to greenery. In the past, blocks of flats were built located much further apart from one another. As a result, there is much more free space between these blocks than between those being built now. The Tócskört housing estate in Debrecen is a good example of this. Residents of the socialist-era housing estate, in which blocks of flats are between four and ten storeys high, have access to the largest number of UGSs in the city (within a 300-m radius of where they live) (Farkas et al., 2022.). Building density is extremely important in the context of the present research topic. The percolation capacity of the surface is widely recognised as a decisive factor in ensuring the rapid neutralisation of heavy rains (Strohbach et al., 2019).

4.2. Legal context

The countries of the European Union (EU) have particularly ambitious climate protection plans. For this reason, the requirements regarding many ecological elements, including water protection rules, are regulated by appropriate directives. The most important directives in this area are the *Water Directive* (Directive 2000/60/EC) and the *Wastewater Directive* (Directive 91/271/EEC). All Member States have been obliged to bring their legislation in line with these directives. In the case of Hungary, EU regulations related to the Water Directive have been transposed into the *Government Decree of July 21, 2004*, on certain rules for river basin management. Both the *Act of 23 June 1995 on Water Law* and the

Act of 22 June 1995 on the Environmental Protection Law have been modified several times since 2000, which modifications have not affected rainwater management issues.

In Poland, these EU directives were transposed mainly in the adoption of the *Act of 18 July 2001 on Water Law and the Environmental Protection Law*. Also of importance in this respect was the regulation of the Minister of the Environment of November 18, 2014, which specified the conditions to be met when discharging sewage to water or land and regarding substances that are particularly harmful to the aquatic environment. In subsequent years, the above-mentioned legal provisions were updated, improved and elaborated in greater detail. A good example of this is the guidelines regarding rainwater and meltwater, which in the above-mentioned *Water Law Act* (of July 18, 2001) were treated on an equal footing with sewage. It was only with the adoption of the new *Water Law Act* in 2017 (Journal of Laws of 2017, item 1566), in which rainwater and meltwater ceased to be equated with sewage, that a new approach to this issue could be taken. Currently, rainwater and meltwater are defined in the *Act* as water resulting from atmospheric precipitation. Therefore, this is no longer sewage that requires absolute treatment.

Standards for wastewaters discharged to surface waters apply to public works as well, whether they carry wastewater or rainwater or both, are contained in the ordinance of the Minister of the Environment and water management of December 25, 2004 on limit values for discharges of water pollutants and certain rules for their application. Standards for the emission depend on the category of the recipient water body. Ephemeral or intermittent watercourses are more vulnerable, so standards are more stringent. The recipient of the Debrecen wastewater treatment plant and public works is an ephemeral watercourse. According to the *Government Decree of April 29, 2010* on general rules applicable to activities and installations for the use, protection and prevention of damage to water, the mixture of urban wastewater and rainwater collected by a combined system may be discharged through an overflow structure bypassing a wastewater treatment plant only after it has been diluted to a defined level appropriate to the load capacity of the recipient. The environmental quality standards for all the 25 types of surface water bodies are regulated in the ordinance of the Minister of Rural Development of August 18, 2010. These standards need to be met irrespective of the number or type of discharges on the water body.

Another important legal aspect related to rainwater is the functioning of storm overflows. Requirements for the operation of storm overflows in Poland are governed by the regulation of the Minister of Maritime Economy and Inland Navigation of July 12, 2019 (Journal of Laws of 2019, item 1311). According to the regulation, the average annual number of discharges from individual overflows should not exceed ten. Compliance with this condition is assessed based on the annual average number of discharges from individual storm overflows of a municipal combined sewage system, as determined on the basis of observations of the operation of overflows for a period of at least two years. In the case of discharges from the municipal combined sewage system for agglomerations of 100,000 or more inhabitants, the average annual number of sewage discharges is determined on the basis of simulation models. However, as Sakson et al., (2017) note, the requirements set out in the Polish legislation regarding the operation of storm overflows are very imprecise. They point out the lack of clarity as to how to count individual phenomena. They also emphasise the imprecision in calculating penalties for excessive use of storm overflows. No specific regulation for the annual number of overflows exists in Hungary.

In addition to the above-mentioned legal acts, several other acts and executive acts contain legal regulations related to rainwater management in Poland and Hungary. In the case of Poland, these include, e.g., the *Act of April 27, 2001, the Environmental Protection Law* (Journal of Laws 2001, No. 62, item 627), the *Act of March 21, 1985 on public roads* (Journal of Laws 1985, No. 14, item 60). In the case of Hungary there are (beyond those already mentioned) the *Act of March 21, 1988 on Public Roads*, the *Act of December 28, 2011 on Local Governments and the Government Decree of December 23, 2000 on designating surface waters and their catchment areas sensitive for urban waste water treatment*. This *Decree* lists the settlements where the recipient of the treated wastewater is sensitive to eutrophication and where the recipient serves as a drinking water resource. The main objective of these legal acts is to ensure the rational use of water resources in accordance with the principles of sustainable development.

4.3. Planning context

In Poland and Hungary, urban development is bringing rapid spatial changes. However, the countries differ in spatial planning requirements.

The planning context is a very important element that should always be taken into account in urban rainwater management. This is because it is downstream of, and thus highly impactful on, various rainwater-management-related issues.

In Poland, the goals and directions of the state's spatial policy emphasise that urbanisation processes must not disturb the rational proportions between biologically active areas and built-up areas. The most important planning document in urban areas in Poland is the spatial development plan. It indicates the purpose of an area and the location of public-purpose investments, and it determines the development method and development conditions for that area. There are very few legal regulations in Polish legislation that, at the national level, define spatial development requirements for rainwater management. One noteworthy legal regulation concerns the requirement to designate at least 25% of a building plot area as a biologically active area (*Regulation of the Minister of Infrastructure 2002*).

In Hungary, a landscaping and green infrastructure development proposal that includes rainwater management is an obligatory element of the supporting proposal for the local urban master plan. The final urban development plan sheet will plot the spatial relationships of development action areas, along with the layout and settlement structural connections between existing and planned green infrastructure elements. The Hungarian Government Decree of July 15, 2021 on the content and procedure of town planning defines different zones for different types and sizes of buildings, along with the maximum permissible built-in area and the minimum vegetated area as percentages. Local building codes may be more stringent. Local building codes in Debrecen permit built-in areas within a plot ranging between 20 and 80% and the minimum vegetated surface is also variously defined in the range of 10–65%. There is always a difference of 20–30% between the sum of these two and 100%, and this difference allows for other sealed surfaces outside the building. The intensity of biological activity is measured by the Biological Activity Value, which makes this value an exact, countable measure. The Biological Activity Value concept was introduced by the *Act of 24 July 1997 on shaping and protecting the built environment, modified 1st May 2006*. The concept of biologically active areas is precisely defined along with the calculation which is described clearly in the *Ordinance of the Hungarian Minister of Local Governments and Spatial Development of April 3, 2007 on the calculation of the biological activity value of areas*. This calculation must be carried out when

the *Master Plan* of a settlement is modified, and it must be proved that the biological activity of the built-in area is not decreased by the conversions in land use. When it is decreased, a compensation area of the same value must be provided.

However, as M. Surma (2015) points out, the concept of biologically active areas is not clarified in the Polish legal regulations. As a result, the value of the ecosystem is entirely disregarded. Therefore, in the current legal situation, a lawn and a wooded area, for example, have the same natural value (on a building plot of the same size). In Poland, housing estates, public utilities and service facilities are being built in which ecological factors (including rainwater) play a key role. Unfortunately, such investments are the exception rather than the rule. The main reason is the lack of appropriate legal regulations requiring that investors meet appropriate urban planning standards regarding rainwater management.

At the national and local levels (in both countries), studies on rainwater management have been developed in recent years. Planning and strategic studies deserve special attention. They are intended to set goals and methods of action in the field of rainwater management. On a local scale, a good example is the *Rainwater and Meltwater Management Strategy* for the city of Wrocław (Sumiński, 2023). The document contains detailed guidelines on the actions that must be taken for the city of Wrocław to achieve sustainable management of rainwater. An example of a country-wide study is the Hungarian *National Water Management Strategy* (Plan Kvassay Jenő KJT), which emphasises the importance of rainwater management.

4.4. Economic context

Water is increasingly being dealt with in economic terms – as an economic good. In Hungary and Poland, the scarcity of water resources is increasingly determining the countries' introduction of appropriate economic instruments designed to contribute to saving water and reducing consumption. In the case of rainwater, the simplest and most frequently used instrument is the introduction of a fee collected from property owners – a so-called “rain tax”. Its level ultimately depends on the amount of precipitation and the building area. In Poland, many cities collect such a fee. It should be noted that local government authorities have adopted various legal solutions and regulations in this area. Therefore, the detailed method for calculating the fee and determining the size of the

fee vary from city to city. In Hungary no such fee has been introduced – at least not separately from the fee collected for wastewater collection and treatment. Since all the cities operate combined sewers, this fee will necessarily include the cost of collecting and treating runoff water as well, but it is not traceable in the bill.

Many urban projects related to the development of BGI and LID are currently being implemented in Poland and Hungary. These projects are partially or fully financed using EU funds under various programmes. The implementation of BGI and LID projects is quickly bringing tangible benefits. It allows not only for rainwater to be collected to avoid damage or inconvenience, but also for its direct use later (*IWA Review*, 2015). Local authorities often introduce additional financial or procedural incentives to motivate investors to include BGI, SUDS and WSUD solutions in their project designs. For example, in Hungary, the operator of a municipal drainage system may prohibit the discharge of rainwater into the combined sewage system. This solution is practised in Debrecen. The minimum requirement is that runoff be stored on the property until the rainfall ends. In this case, the owner must build and operate a retention tank for water flowing from the roof or find another solution without connecting to the sewerage system. It should be noted that this does not result from a legal regulation. However, these requirements are taken when building permits are being sought.

In both countries, as in most well- or moderately developed countries, rainwater cannot be directly used for consumption purposes (Stec & Słyś, 2017). This is prohibited by applicable regulations due to the excessive contamination of rainwater. However, rainwater may be a good substitute for mains water for washing a car, flushing the toilet, washing and irrigating lawns or field crops (Ghisi et al., 2009; Jones & Hunt, 2010). The use of rainwater for these requires that certain investments be made. However, such investments are justified for residents, enterprises and institutions only if they are economically profitable. In Poland, the research to date has provided ambiguous information on the economic feasibility of such investments. The profitability of investments in rainwater collection has been demonstrated for a multi-family residential building (Słyś et al., 2015; Sakson, 2018) and a student dormitory (Stec & Słyś, 2017). However, lack of profitability has been demonstrated for a single-family building (Słyś et al., 2015; Sakson, 2018). As noted by Musz-Pomorska et al., (2020), investing in rainwater collection for single-family buildings in Poland is only profitable with significant

financial support in the form of national- or local-government subsidies.

According to a Hungarian case study carried out for a single-family house with four persons living in it, 77 euros can be saved annually if rainwater is directly used only for irrigation, cleaning, washing and toilet flushing, which together cover 54% of the average daily water demand (Fórián, 2009). However, it is not only the annual volume of water that will ultimately define the economic benefits, and this study does not provide economic conclusions. Another article focuses on the usage of LIDAR technology in determining the volume of harvested rainwater. Based on the results presented, LIDAR technology has provided accurate data for assessing built-in areas, urban runoff conditions, cistern design and rainfall utilisation (Tamás et al., 2019). The increased volume of runoff and the resulting problems are the main driving force of such studies in Hungary, rather than the direct usage of the harvested volume of water.

5. Discussion and conclusion

The policy of national and local authorities is extremely pertinent when introducing and implementing activities related to broadly understood environmental protection (including climate change). The reason is usually that such investments are not directly profitable. This obliges political authorities to introduce appropriate legal regulations in order to achieve the intended environmental effects. Environmental issues are a major area of interest for EU institutions. Therefore, legal regulations on environmental protection in EU countries are quite restrictive. As already noted, both Poland and Hungary, upon joining the EU, were obliged to implement the appropriate directives regarding the protection of water resources. The *WFD* played the greatest role in this respect. It obliged member states to, for example, develop water management plans for each river basin area (*River Basin Management Plan – RBMP*) designated in a country. These studies are reviewed and updated periodically every six years based on planning documents indicated in the *WFD* and national legislation. The mentioned *RBMPs* not only shape water management but also affect other sectors, including industry, municipal economy, agriculture, forestry, transport, fishing and tourism. *RBMPs* should be included in planning documents at national and regional levels. They are also important for urban areas. The *RBMP* developed for

the Tisza River catchment, which includes the city of Debrecen, is a good example. The study indicates the poor quantitative condition of the aquifer from which water is drawn for the inhabitants of Debrecen. The annual volume of water withdrawn is higher than the supply to the aquifer. Excessive use of groundwater resources can lead to high stress on aquifers and the serious depletion of groundwaters (Custodio, 2002; Gleeson et al., 2012; Famiglietti, 2014). This condition may further worsen as a result of increased water consumption during periods of drought (Taylor et al., 2013; Russo et al., 2017). The *RBMP* for the Tisza catchment indicates the remedial measures that must be taken to prevent further negative consequences of increased groundwater extraction. They include rainwater retention and greater expansion of BGI in Debrecen.

In recent years, the largest cities in Poland and Hungary have undertaken to develop climate change adaptation plans. It should be noted that in both countries the information, data and analyses used in the resulting studies vary. However, in both cases the main goal was to develop an integrated approach to climate change mitigation and adaptation. A key part of these studies is the management of water, including rainwater. The development of these studies should be assessed as very positive, as they often indicate in great detail the local-scale consequences of climate change. At the same time, these documents contain information on actions that should be taken to eliminate or minimise these changes. Some of the solutions proposed in the climate change adaptation plans are universal and concern increasing the retention of urban catchments by using various BGI solutions, and the choice of specific solutions depends on local factors. Some climate change adaptation plans indicate very original and specific solutions. An interesting example is the CIVAQUA project developed for the city of Debrecen. This project involves the transfer of water within the same catchment area by approximately 17 km from an existing irrigation canal fed by the Tisza River. Its implementation is intended to, among other things, help save the largest public green space in Debrecen – Nagyerdő Park (Farkas et al., 2022). It should be noted that the Debrecen climate change adaptation plan does not mention any need to take action to supply Nagyerdő Park with rainwater from the park's surroundings. This is particularly important bearing in mind that the park is 70% surrounded by built-up areas with impermeable surfaces.

The climate change adaptation plans developed for Poland's largest cities (45 cities) gave many local governments significant impetus to act on rainwater

management. Currently, one of the largest projects in this field is being implemented in Bydgoszcz. Its aim is to adapt the city's rainwater system to the current and planned land development method. The project will also limit the negative effects of heavy rains and large amounts of rainwater and meltwater to minimise the flooding of buildings and streets.

The project includes the building of 14 km of rain sewers and the renovation of 90 km. In addition, 81 different BGI facilities for rainwater management are to be built. The project is valued at EUR 60 million (at EUR 1 = PLN 4.3) and includes EU funding of EUR 36 million (under the national programme: Operational Programme Infrastructure and Environment). The cost of implementing the project is significant, especially considering that the city of Bydgoszcz has an annual revenue of approximately EUR 553 million (data for 2023 Bydgoszcz City Portal 2023). Without external financial support, this project would probably be impossible to implement. Work on modernising the sewerage network and constructing retention facilities and other BGI features requires very large financial outlays. Therefore, financial issues should be considered the main limitation on implementing comprehensive rainwater management projects in cities. It is far more common, in cities in Poland and Hungary alike, for small, usually pilot projects to be implemented. They are often initiated by non-governmental organisations or local associations. These projects are extremely valuable, primarily for educational reasons, as they show the general public the practical possibilities of rainwater management. However, in relation to an entire city, they are usually not significant.

As already mentioned, Polish and Hungarian legislation has included the issue of rainwater in many Acts. In addition, a number of other studies and documents have been created at the national and local levels that constitute guidelines, recommendations, plans and action strategies for sustainable rainwater management. Despite this, there are still many areas related to urban rainwater management that need improvement. Zwęgliński & Balatonyi (2021) have pointed out that rainwater management in Hungary is quite poor. In Poland, there is a noteworthy number of entities involved in the process of rainwater management in cities. As K. Rosiek (2023) notes, they currently range from six to over ten. This is highly relevant to the coordination and effectiveness of implementation of individual measures. However, the most serious doubts are related to the interpretation of certain legal provisions or lack thereof. In Poland, one example is the legal provisions' lack of definition for

the terms “dry wells” and “rain gardens” (Sobota et al., 2022). This fact should be considered undesirable because it reduces the certainty of legal transactions in the applicable legal system (Sobota, 2021). The regulations regarding fees for rainwater discharge are also imprecise (Słyś et al., 2015). It should also be noted that inappropriate legislation is considered one of the key barriers to the development of BGI in many other countries around the world, including in Australia, Great Britain, the United States, China, New Zealand and Germany (Sobota et al., 2022).

The development of sustainable rainwater management systems in cities is one of the current key issues related to climate change. The examples of Polish and Hungarian cities discussed in the work indicated a diversity of approaches to selected elements of the research topic. In both countries, mainly as a result of accession to the EU, there have been significant legislative changes in the field of rainwater management over the last two decades. Many of the changes introduced should be assessed positively. However, there are still areas requiring appropriate legal regulations. National and local authorities in both countries are taking measures to slow outflows and to manage rainwater within catchment areas. To this end, various projects are being implemented that are usually pilot projects. Projects, especially educational ones, initiated by local communities are also important. The main impediments to a comprehensive solution for the sustainable management of rainwater in urban areas in Hungary and Poland are financial. It should be noted that this is a common problem and affects virtually all countries around the world. This results from the need to renovate and often to intervene heavily in the existing urban infrastructure. This generates significant costs and, often, cultural and aesthetic conflicts. Nevertheless, climate changes will determine the need to implement various BGI solutions in urban areas in the coming years. The documents and strategic studies mentioned in the work indicate that the Polish and Hungarian authorities recognise this problem. The coming years will allow us to assess the appropriacy of the strategies and plans adopted and the effectiveness of the infrastructure projects implemented.

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