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ANALYSIS OF OPERATOR MODELS FOR RAINWATER MANAGEMENT IN POLAND – TOWARDS THE INTEGRATED MANAGEMENT MODEL

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ABSTRACT: Over the last decade, Poland has witnessed a statutory change in the definition of rainwater. It stopped being regarded as wastewater. Municipalities in Poland have developed different models for rainwater management and various ways of financing them. The aim of the study is to identify and to describe the most important elements of rainwater management models in Poland with the use of operators. It focused not only on constitutive features of the system, but also on financial aspects, such as fees and investments (with the omission of fiscal ones). The study helped to identify three organisationally distinguishable operator models and indicated strengths and weaknesses of each of them. Such a systematic and structured analysis lays the groundwork for the assessment of these models and enables other municipalities to make a conscious decision on which model to implement.

KEYWORDS: rainwater/stormwater management

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Introduction

For decades, Poland's legislation has defined rainwater as wastewater. As a result, rainwater had to be discharged to a sewage plant if it contained domestic wastewater or, otherwise, directly to surface waters. The change of Poland's Water Law regulations, alongside with the statutory change of the definition for rainwater, allowed for a different mode of management. However, it also generated numerous problems arising from the fact that there are many regulations that control rainwater issues, and that the amendment to the act did not address a significant part of them (including regulations concerning fees for discharging rainwater). At the same time, Poland's cities began to build rainwater and snowmelt management systems. Several cities started to identify issues concerning drainage infrastructure earlier than the other ones, and proceeded to implement innovative technical, as well as organisational solutions. We must note that this process primarily took part in big and middle-sized towns. We can assume, with a certain degree of concern, that the change of rainwater management and guarantee of investment means/resources for the necessary undertakings are the challenges most of cities in Poland currently face. Additionally, all of the above challenges stem from the climatic transformation. These cities learn from the experience of leaders, i.e. cities that have already undertaken such a project.

We should, therefore, ask the question why not draw on models from other European countries, or even North America. Technical solutions and general recommendations for the direction of such a change – the implementation of sustainable urban water management – are relatively easy to implement. However, on the level of specific organisational solutions, among the factors determining the whole process are the existing legal framework and available sources of financing. It is difficult to copy ready solutions from other countries, as they might be inapplicable, due to legal and, quite often, cultural differences.

Therefore, it seems extremely important to identify, analyse, and indicate weaknesses and strengths of the models for rainwater management existing in Poland. The study described in this article aims to achieve it.

The inspiration for the study was the conference presentation by W. Sumisławski, *Rainwater and snowmelt management models in Poland* (Sumisławski, 2021). However, the scope of this study has been widened, more detailed and, above all, systemised. The results have been presented in a uniform and comparable way. The names of the models, each of which contains the name of the city which has implemented it, are borrowed from the aforementioned author, but their categorisation is the contribution of the author of this article.

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The subject of the analysis are models for rainwater management in which the affiliated entity exists as the operator, or is given this role. In Poland, tasks of rainwater management can also be carried out without appointing such an entity.

The article starts with a literature review, which has been carried out from the perspective of various approaches to changing water management systems in urban areas, towards integrated water management. The author draws a parallel between the most interesting approaches: their changes in time, but also between system solutions that currently function in different regions, with references to areas in which they are most popular (chapter 1). In the part devoted to materials and methods (chapter 2), the author indicates the scope, method and time of the study and briefly refers to legal frameworks, both in the EU, and in Poland. This part of the article also describes dilemmas which arise from the ambiguity of Polish legislation in this field. Chapter 3 aims to present the study results. It describes models according to chosen analysis criteria and their graphical mapping is attempted. The author also discusses the strengths and weaknesses of each approach. The article ends with conclusions drawn on the basis of the study.

Literature overview

It seems that, in this day and age, no one needs to be persuaded that water is one of the most precious natural resources. Historically, the development of civilisation has been, and still is related to water, which often has been the cause of conflicts (Kowalczak, 2007; Kowalczak & Kundzewicz, 2011; Water Conflict Chronology, n.d.; Water, Security and Conflict, 2018). In general, we can identify several reasons for shortage of freshwater accessible to society and the environment. They include: catastrophic climate changes (AR6 Climate Change 2022, n.d.; Bates et al., 2008; Gleick, 1998; Grafton et al., 2013; Letcher, 2022; OECD, 2010, 2013; Shrestha et al., 2014; Stucker & Lopez-Gunn, 2017; Taylor et al., 2013; Tortajada et al., 2016; Whitehead et al., 2009), urban processes and other processes related to population growth (Eikenbery, 2003; Kumar, 2021; U. W. W. A. Programme, 2020; W. W. A. Programme, 2012, p. 3; WCPI Map, n.d.), as well as population growth in towns (an increase from 43% in the year 1900 up to 57% in the year 2001 on the global scale (World Bank). In the year 2007, the number of urban populations exceeded the number of rural populations (Ritchie & Roser, 2018) and, in some parts of the world, they exceed this level on average. The post-war reconstruction of Europe gave rise to many processes connected with urban modernisation, which often involved widening streets, creating city squares and closing surface waters in canals. Concrete became a synonym for a mod-

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ern, clean and modernistic city, especially in the Eastern Bloc countries (the Communist Bloc) (Hirt, 2013; Mencwel, 2020; Stanilov, 2007). Water, beyond urban park spaces, became absent from cities. According to this approach, rainwater – often regarded as a threat--was to be discharged from a city as quickly as possible. Cities became separated from their rivers by high flood embankments. Those processes were, in fact, ineffective; especially with an increase in surface sealing in cities, which accelerated ground run-off and contributed to increases in flood waves.

To put it simply, approaches to rainwater can be divided into:

- a "withdrawing water from people" approach, involving the construction of anti-flood infrastructure, which – unfortunately – leads to floodplains development,
- a "withdrawing people from water" approach, which is the next stage where efforts are made to guarantee space for water in cities.

However, the most complex approach is sustainable and integrated water management in a city, based on blue-green infrastructure and run-off delay, which also includes changes in rainwater management (Table 1). In this approach, rainwater must be treated as a resource, and not wastewater.

A perfect analysis of the changing approach to urban water has been offered by Brown and his team (Figure 1). They have indicated both social and political causes for the introduced changes. Out of necessity, the first stage is the guarantee of potable water access, the second one is the guarantee of sewerage access (public health protection), the third one is flood protection, which involves city drainage. In other stages of the approach, environmental factors, such as the elimination of pollution, especially point pollution, start to play a role. Water scarcity and water access limit are the cause of the implementation of further changes. The last stage involves the implementation of sustainable development (including intergenerational equity), introduction a concept of resilience city, which adapts to climate change, where constructed infrastructure – based on nature based solutions (NBS) and blue-green infrastructure (BGI) – is multifunctional, inhabitant-friendly, and contributes to better quality of life. It must be noted that, in different parts of the world, or even within one country, different cities will display various approaches, on different levels of development.

Analysing the scheme below (Figure 1), we must note its usefulness for planning and management processes because, once we have the awareness of undergoing processes, we can take actions to make use of the so-called lagging gap and skip stages to go towards Water Resilient City or Water Sensitive City.

Table 1. Approaches to water management in urbanised regions

Concept	Withdrawing water from people	Withdrawing people from water – room for river	Sustainable and integrated water management
Characteristic activities	River regulation, embankment construction	Limiting construction on floodplains	Planning from the perspective of the whole catchment area
	Stream management, sewage system, surface waters regulation	Moving critical infrastructure out of floodplains	Analysis of what causes an issue, consideration of anthropogenic processes
	Fast rainwater discharge „from the cloud to the pipe"	Special technical specifications for buildings situated in regions exposed to the risk of flooding	Introduction of varied tools involving blue-green infrastructure
	City drainage, wetlands drainage	Embankment retraction, creating artificial reservoirs for rainwater or flood waves	Prevention of rainwater run-off, retention in the rainwater spot
Procedure	Point approach – performing actions in places where an issue occurs, or ones oriented towards solving a specific issue	Process approach – planning oriented towards minimizing damage	Integrated approach based on risk assessment and establishing its acceptance level by stakeholders
Idea	Water as a threat for people and their property, a solution will help to tame water	Water as a threat to people and their property, recognition of a need for a water reservoir, damage prevention	Water as an integral part of the urban environment which improves quality of life, acceptance of a specific risk level for damage occurrence
	Water away from people	Water near people	Water with people
Rainwater treatment	Fast undisturbed rainwater discharge from a city, drainage through creating expensive underground rain sewerage infrastructure that is used incidentally	Constructing retention reservoirs including dry, ground and underground ones with the purpose to catch excess rainwater and delay its run-off	Integrated rainwater management as part of sub-basin, reducing rainwater inflow into grey infrastructure through its catchment in BGI

Source: author's work based on: Bahri (2012); Krauze, & Wagner (2014); Mrowiec (2020); Rosiek (2016); Tvedt & Oestigaard (2014).

The relations between urban water, including rainwater, and quality of life, flood threat and pressure on the environment are examined worldly and in Poland. While in the USA, Low Impact Development (LID) is dominant, in Europe the approach promoted by The Economics of Ecosystems and Biodiversity concept (TEEB), as well as the use of Nature-Based Solutions (NBS) and Blue-green infrastructure (BGI) is preferred. Sustainable Urban Drainage Systems (SUDS) have been developed in Great Britain, while in Australia Water Sensitive Urban Design (WSUD) is implemented. Integrated Urban Water Management (IUWM) is widely promoted by the UN in many countries.

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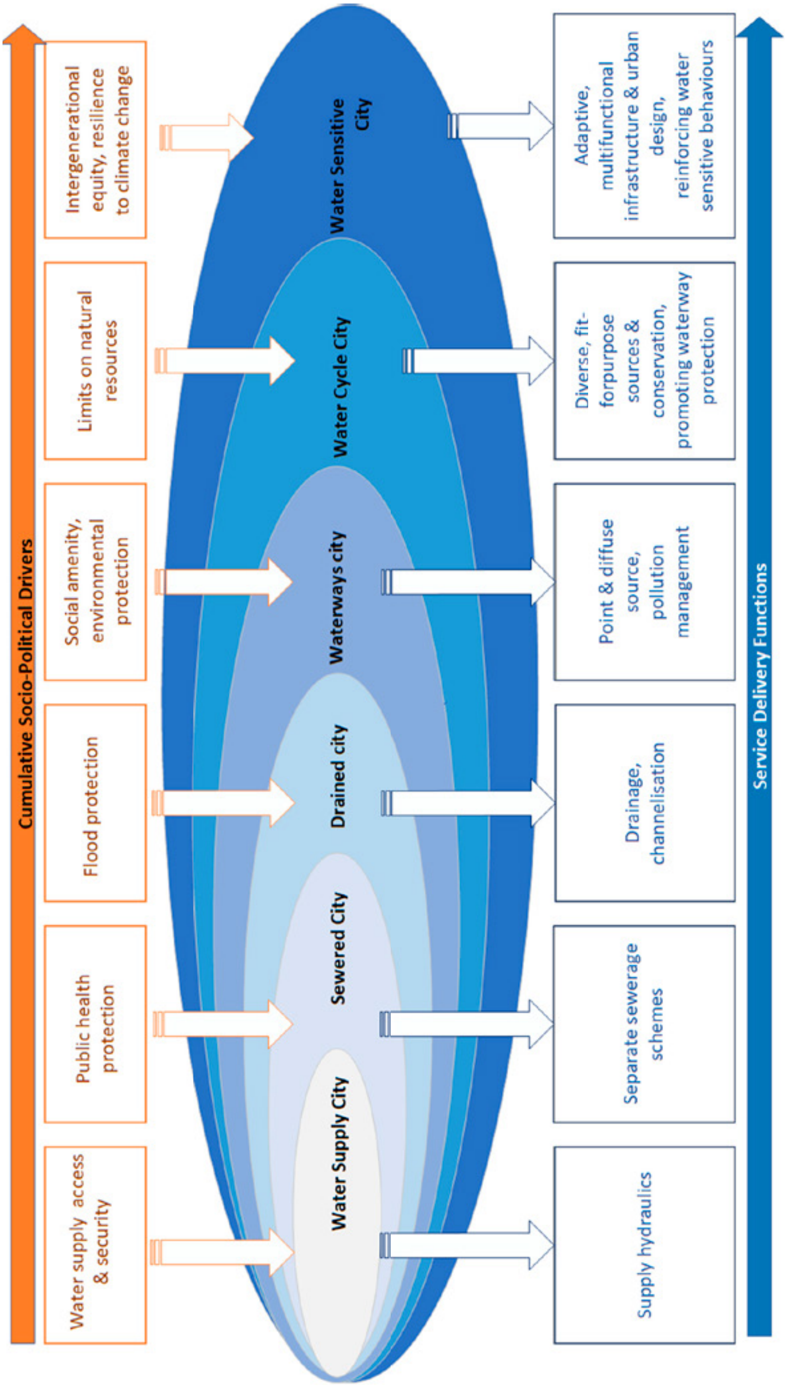

Figure 1. Urban Water Management Transition Framework

Source: Brown et al. (2008).

DOI: 10.34659/eis.2023.85.2.554

The summary and comparison of the above mentioned concepts are included in Table 2.

Table 2. Chosen contemporary water management tools and concepts

Concept	Characteristic
LID – Low Impact Development	Aims at the restoration of possibly nature-like hydrological conditions with the use of: natural processes, landscape and integrated control tools, the balance of run-off volume, infiltration and evapotranspiration, achieved by „functionally equal hydrological landscape". The aim is to minimise the costs of rainwater management, while encouraging nature-based solutions. Rainwater is treated as a resource, not wastewater. (the USA, Canada, New Zealand)
WSUD – Water Sensitive Urban Design	Aims to minimise the hydrological impact of urban development on the surrounding environment. However, in practice, it is associated with rainwater management oriented towards ensuring flood risk control, improving water quality and creating opportunities for economic rainwater use. (Australia)
SUDS – Sustainable Urban Drainage Systems	Based on recreating and using natural water cycle processes, involves rainwater management solutions in a way that is more sustainable than conventional solutions. It applies to both quality and quantity. (Great Britain)
IUWM – Integrated Urban Water Management	Applies to the integrated management of all water cycle elements in a basin, combines water supply management with underground water management, city sewage and rainwater. It also deals with institutional issues and emphasises the importance of local communities in the process of creating such infrastructure. (UE, promoted by UN Department for Sustainable Development, e.g. in South America, Africa and India)
TEEB – The Economics of Ecosystems and Biodiversity	International initiative aimed to draw attention to global economic benefits offered by nature. It also emphasises the importance of biodiversity whose loss or degradation generates costs for cities. TEEB is administered by United Nations Environment Programme (UNEP), with the help from the European Commission and governments of different countries.

Source: author's work based on: Eckart et al. (2017); EPA (2007); Fletcher et al. (2015); Krauze, & Wagner (2014); Mader et al. (2011); Mrowiec (2020); Parkinson et al. (2010); US EPA (2015).

Fletcher and his team have described differences between the above tools and concepts (Figure 2). Yet, Fletcher points out that the terminology is flexible and the figure presented below should be treated as a generalisation, not a rigid classification. It should be noticed, however, that these approaches show a shift of interest: from rainwater and sewage quality improvement (in the context of water resources protection), to the approach where the primary focus is on urban water cycle restoration, possibly nature-like, with the use of BGI and NBS. We can also observe a transition from the tool approach to concept creation. Nevertheless, the figure clearly shows that the presented tools and concepts simply interface in certain areas, use the same background and similar technological and organisational solutions. Often, differences stem from the fact that they originated in different geographical regions (South America, Australia, Europe).

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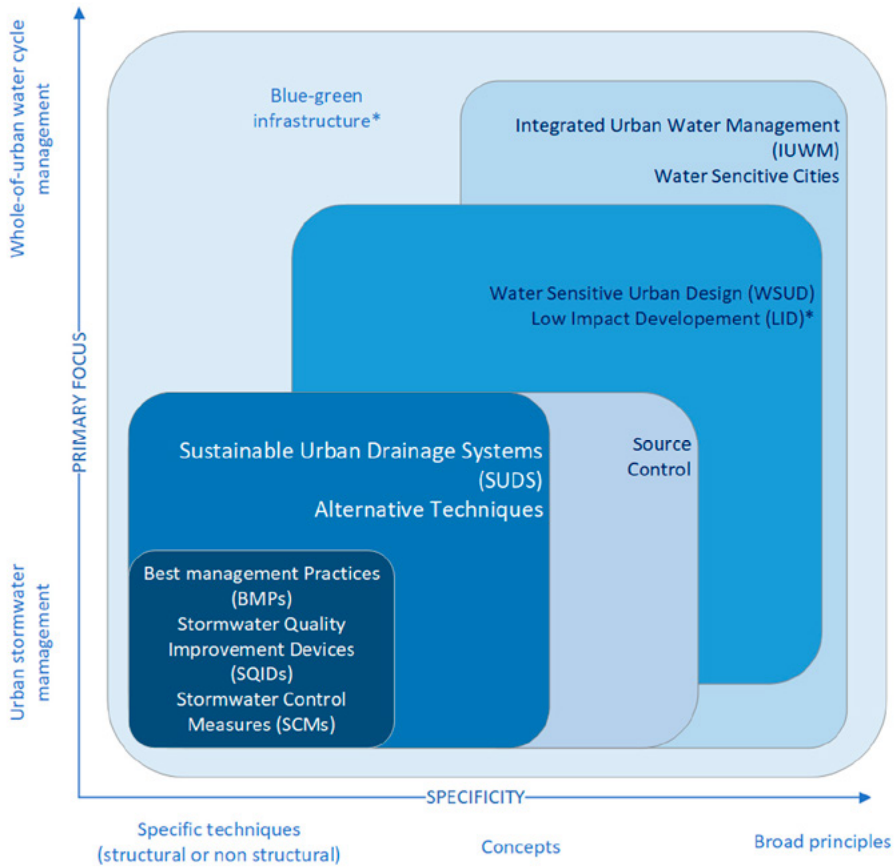

Figure 2. Dependence between different water management tools and concepts

* modified from the original

Source: Fletcher et al. (2015).

The article neither aims to decide whether all the mentioned approaches (Table 3) are identical, nor focuses on differences between them. It can be generally agreed that these approaches are to meet the same objective – water management improvement, with the purpose to protect water resources, as well as improve human quality of life and make cities more resilient and liveable in the age of the climatic disaster. Taking into consideration the fact that IUWM is the widest concept, widely promoted and recognised in the world (Furlong et al., 2017), further considerations will be based on it.

IUWM is a comprehensive approach to water management in urban and rural areas. It combines economic, social and environmental spheres with political aspects and with planning. To put it simply, the aim of IUWM implementation is the transformation of water users to water managers. It is expected to ensure better and more economical use of water resources, the improvement of their quality and accessibility, the improvement of water supply and sewage collection efficiency, the reduction of water loss, and the change of consumption habits. However, it requires the cooperation between the private sector, the public sector and the society. It also involves changes in urban development and its use. Yet, the most important change aspect is to ensure the cooperation between all water users. The differences between the traditional water management and the integrated one are presented synthetically in Table 3.

IUWM (Bahri, 2012, p. 14): "offers a set of principles that underpin better coordinated, responsive, and sustainable resource management practice. It is an approach that integrates water sources, water use sectors, water services and water management scales:

- It recognises alternative water sources.
- It differentiates between the qualities and potential uses of water sources.
- It views water storage, distribution, treatment, recycling, and disposal as part of the same resource management cycle.
- It seeks to protect, conserve and exploit water at its source.
- It accounts for nonurban users that are dependent on the same water source.
- It aligns formal institutions (organisations, legislation, and policies) and informal practices (norms and conventions) that govern water in and for cities.
- It recognises the relationships among water resources, land use, and energy.
- It simultaneously pursues economic efficiency, social equity, and environmental sustainability.
- It encourages participation by all stakeholders".

Table 3. Integrated management vs. traditional management methods

Traditional management	Integrated management
Water and wastewater systems are based on historical rainfall records*	Water and wastewater systems rely on multiple sources of data and techniques that accommodate greater degrees of uncertainty and variability*
Water follows one-way path from supply, to single use, to treatment and disposal*	Water can be reclaimed and reused multiple times, cascading from higher to lower quality*
Rainwater is a nuisance to be conveyed quickly from urban areas*	Rainwater is a resource to be harvested as a water supply and infiltrated or retained to support aquifers, waterways, and vegetation*

DOI: 10.34659/eis.2023.85.2.554

Traditional management	Integrated management
Human waste is a nuisance to be treated and disposed*	Human waste is a resource to be captured, processed, and used as a fertiliser*
Linear approaches deploy discrete systems to collect, treat, use and get rid of water*	Restorative and regenerative approaches offer integrated systems to provide water, energy, and resource recovery linked with land-use design, regulation, and community health
Demand equals quantity. Infrastructure is determined by the amount of water required or produced by end-users. All supply-side water is treated to potable standards; all wastewater is collected for treatment*	Demand is multifaceted. Infrastructure matches characteristics of water required or produced for end-users in sufficient quantity, quality and level of reliability
Grey infrastructure is made of concrete, metal, or plastic*	Green infrastructure includes soil and vegetation as well as concrete, metal, and plastic*
Bigger is better; collection system and treatment plants are centralised*	Small is possible; collection systems and treatment plants may be decentralised*
Standard solutions limit complexity; water infrastructure consists of 'hard system' technologies developed by urban water professionals*	Solutions may be diverse and flexible; management strategies and technologies combine 'hard' and 'soft' systems devised by a broad range of experts*
Utilities track costs alone and focus on accounting*	Utilities evaluate the full array of benefits from investment and technology choices, and focus on value creation*
The standard is a business-as-usual toolkit*	An expanded tool kit of options includes high-tech, low-tech, and natural systems*
Institutions and regulations block innovation*	Institutions and regulations encourage innovation*
Water supply, wastewater, and rainwater systems are physically distinct. Institutional integration occurs by historical accident*	Water supply, wastewater, and rainwater systems are intentionally linked. Physical and institutional integration is sustained through coordinated management*
Collaboration equals public relations. Other agencies and public become involved only when approval of predetermined solution is required*	Collaboration equals engagement. Other agencies and public are actively involved in search for effective solutions*
Centralised planning and management	Integrated planning and management
Demand approach, taken actions equal demand	Responsive supply approach, taken actions consider resource quantity and quality and diversity of needs
Sewage, rainwater or drainage systems, as well as water supply systems are planned, constructed and managed in an independent way	Aims at interdependence, feedback loop between urban network systems, spatial planning; takes local basin conditions into consideration
Based on expert, sector model	Based on cooperation of experts from various fields as well as a social dialogue and the engagement of all stakeholders
Reactive actions (as a response to an encountered problem)	Active actions prior to potential problems
Based on sequence action, tested and fixed problem solutions	Parallel action based on good practices, pilot programmes, innovative projects

DOI: 10.34659/eis.2023.85.2.554

Traditional management	Integrated management
Interaction with local authorities on a "client principle"	Cooperation between local authorities and a local community, common water resources
Based on present solutions for water and land use	Seeking alternative solutions for space use, space integration, ensuring primary water use or water reuse
Single-functional installation, e.g. rainwater discharge or collection	Multi-functional solutions integrating the issues of the environment, a community and economics
Large-scale projects are often preferred	Small and micro-scale projects are introduced „densely", which can limit the necessity for large-scale project implementation
Based on grey infrastructure	Based on blue-green infrastructure, integration with grey infrastructure and existing natural or semi-natural areas

Source: author's work based on: Furlong et al. (2016, 2017); Guthrie et al. (2020); Rosiek, (2016) and *cite from Bahri (2012).

The transition from traditional methods of urban water management to the integrated approach is, in fact, a demanding process, as it involves the engagement of many stakeholders and a change in the way of thinking about water (education). Urban water must be regarded holistically as a precious resource, including rainwater and non-potable water, i.e. re-used, treated and grey water (Figure 3).

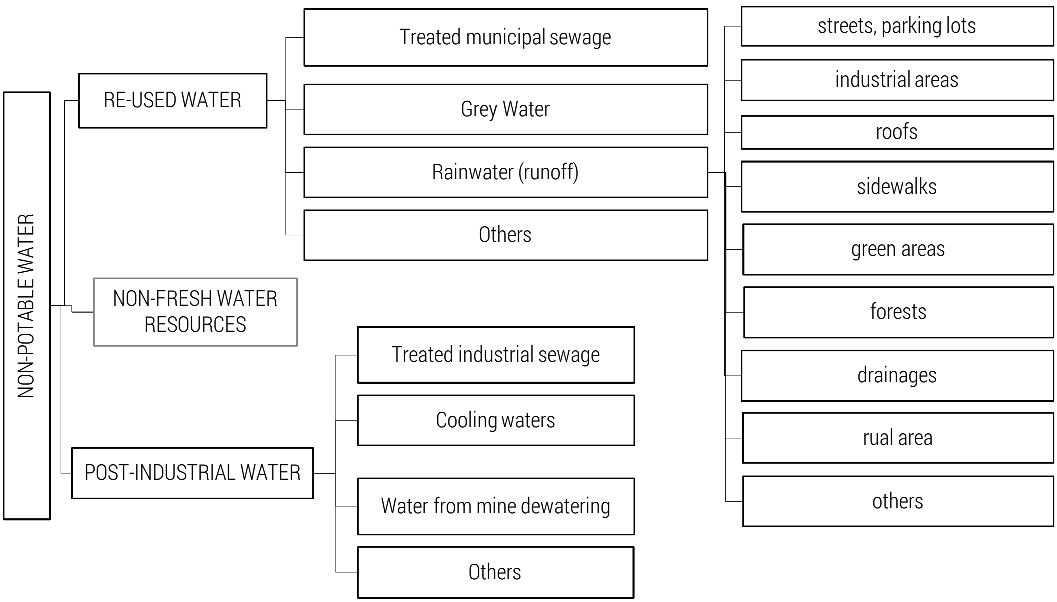

Figure 3. Rainwater, post-industrial water and re-used water

DOI: 10.34659/eis.2023.85.2.554

Materials and methods

Methodology and structure of the research

A literature review and the study of documents strategic for 45 Polish cities have been carried out to identify and describe models for rainwater management in Poland and to assess the level of their integration. Between the years 2020-2022, numerous interviews with entities involved in Poland's rainwater management have also been conducted.

The study includes the cities which took part in the programme for developing urban climate adaptation plans (MPA44, 2017) and Warsaw (MPA Warszawa, 2019), where such a programme was developed within another project. These are the cities with population of more than 100 thousand and also includes several smaller cities functionally connected with the bigger ones (e.g. the Tricity agglomeration: the city of Gdańsk and the city of Gdynia meet the criteria, whereas the city of Sopot does not) or Silesia conurbation. Such a choice of the focus group was purposeful. The analysis included: a systematic overview of strategic documents and other materials (regulations adopted in cities), an analysis of the number and structure of entities engaged in rainwater management, an analysis of economic instruments being implemented, the development of specific models for the most frequently occurring structures, and an analysis of strengths and weaknesses of those models. The following analysis criteria have been chosen to research the specific models:

- constituted feature,
- infrastructure ownership,
- legal basis,
- fee rates for service,
- settlement with users,
- settlement between the operator and the local government,
- investments,
- additional financing from foreign sources,
- assets generated during an investment process.

The study do not consider tax flows.

A research frame constructed in such a manner enables drawing conclusions and comparing identified operator models for rainwater management in Poland.

Rainwater and the EU law

Water issues are managed by substantial EU legislation and are regulated by directives dedicated to the following aspects: urban waste water treatment (Directive 91/271/EEC, 1991), floods (Directive 2007/60/EC, 2007),

DOI: 10.34659/eis.2023.85.2.554

bathing water (Directive 2006/7/EC, 2006), water intended for human consumption (Directive 2020/2184, 2020), groundwaters (Directive 2006/118/EC, 2006), water reuse (Directive 2020/2184, 2020, p. 741), etc. The process culminated in the year 2000 in the so-called Water Framework Directive (Directive 2000/60/EC, 2000), which aims for good qualitative status of water resources. Water Framework Directive also aims for sustainable water use and reduction of drought effects (Directive 2000/60/EC, 2000, art. 1). However, aims connected with water management, including rainwater, are also contained in a number of other documents:

- 8th General Union Environment Action Programme to 2030 (Decision 2022/591, 2022, p. 591),
- Addressing the challenge of water scarcity and droughts in the European Union (COM/2007/0414 Final, 2007),
- Blueprint to safeguard Europe's water resources in 2012 (COM/2012/0673 Final, 2012),
- Blueprint to safeguard Europe's water resources (COM/2012/0673 Final, 2012),
- Green Infrastructure (GI) – Enhancing Europe's Natural Capital (COM/2013/0249 Final, 2013),
- EU Strategy on Adaptation to Climate Change (COM/2021/82 Final, 2021),
- Strategy for Financing the Transition to a Sustainable Economy (COM/2021/390 Final, 2021),
- Circular Economy Action Plan (Resolution 2020/2077, 2021).

We can mention more documents regarding, for instance, biodiversity or urban policy, agriculture and energy production, climate change adaptation, quality and quantity of water resources and, primarily, the European Green Deal.

To systematise the data, we must emphasise that the EU water policy is developed within three pillars: EU water legislation, EU sectoral policy and regional environmental policy. However, we must remember about a significant impact of a horizontal policy, which includes climate change adaptation, transformation to a sustainable and circular economy. Waters, including rainwater, are a significant element of EU environmental and climate policy.

The scope of definitions of rainwater in Polish legislation

To explain the reasons behind the difficulties concerning rainwater management in Poland, it is essential to provide an organisational-legal background. In Poland, water management issues (including rainwater) are regulated by a number of legal acts:

- Water Law Act (Article 1566, year 2017),

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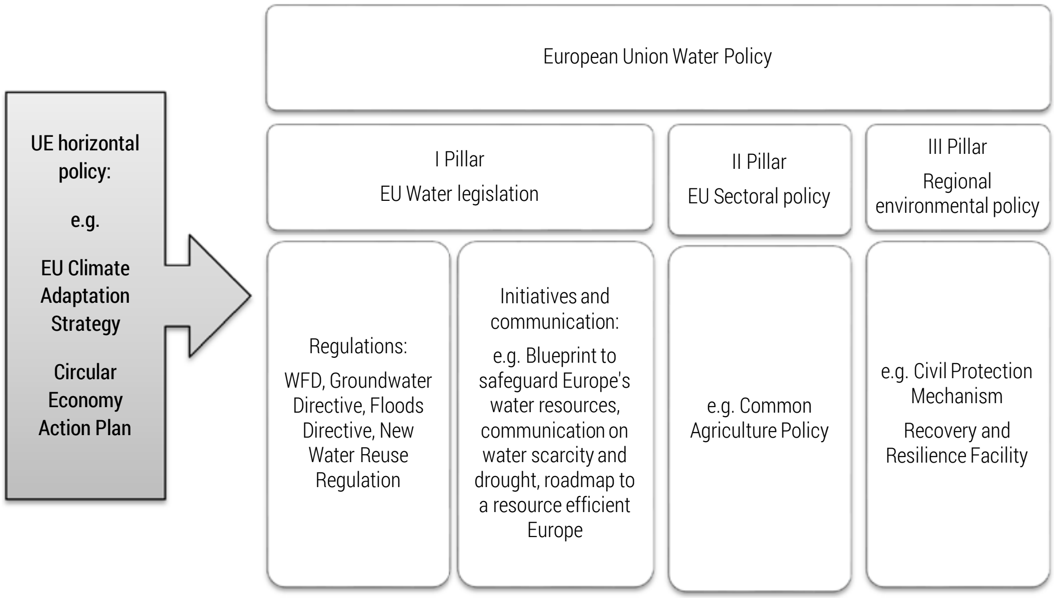

Figure 4. The EU Water policy main pillars

Source: author's work based on EEA, 2021.

- Environment Protection Law (Article 627, year 2001),
- Act on collective water supply and sewage disposal (Article 747, year 2001),
- Waste Management Act (Article 21, year 2013),
- Construction/ Building Law (Article 414, year 1994),
- Spatial Planning and Development Act (Article 717),
- Local Government Act (Dz.U. 1990, Article 95, year 1990, Article 95, year 1995),
- Municipal Services Management Act (*Article 43*, year 1997),

Regulation on disclosure on environmental information and its conservation, public participation in environmental protection and environmental impact assessment (Aricle 1227, year 2008).

Moreover, several implementing acts (in Poland called regulations) and additional norms (for instance construction/ building norms) regulate the issues.

For decades, Poland's Water Law Act defined rainwater as wastewater and, as a result, there was no other way to handle it, but to discharge it through an open or closed sewerage system. The change of Water Law Act provisions in the year 2017 was a turning point for rainwater management in Poland. This statutory change provided a new definition for rainwater and snowmelt, thus excluding it from the automatically-assigned sewage cate-

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gory. Instead, rainwater is defined as water resulting from precipitation. However, this act does not regulate whether and when rainwater/ snowmelt becomes wastewater and we must find applicable regulations in other legal acts. The regulation on substances particularly harmful for water environment (Regulation, 2014) settles the issue. It defines:

- requirements for rainwater discharge to waters or water facilities,
- the highest limit values for pollutants,
- a method for sample water examination and assessment.

The regulation defines parameters for rainwater. Once the parameters are exceeded, rainwater – from industrial areas, storage areas, transport bases, ports, airports, cities, specified national, voivodeship or district (Polish: *powiat*) roads, large parking lots, as well as petrol storage and distribution facilities – cannot be discharged to surface waters without treatment and such rainwater becomes wastewater.

Poland's Water Law Act specifies when rainwater discharge to surface waters is allowed (Article 76, Water Law Act). Rainwater which contains human waste or industrial waste becomes waste itself. The Act also specifies conditions for water discharge from storm overflows to surface waters (Article 80, Water Law Act) as well as several restrictions concerning rainwater management, e.g. a ban on direct rainwater discharge to groundwater (Article 75a, Water Law Act), a ban on snow removal or its storage close to surface waters (Article 77, Section 1, item 2, Water Law Act), a ban on the destruction of water discharge systems (Article 192, Section 1, item 1 and item 3 letter l, Water Law Act) and a ban on a change of rainwater run-off direction and intensity to the detriment of adjacent land (Article 234, Section 1, item 1 and item 2, Water Law Act).

Local plans of spatial development should deal with rainwater management (Dz.U. 2003, poz. 717.). However, current spatial development plans include only about 30% of *gminas'* area (English: *commune*) (BDL K2.G421. P2847, 2021), and many existing spatial development plans are over 10 years old. In older plans, however, a regulation concerning rainwater management only specifies that rainwater must be discharged to a combined or rain sewerage system or, if there is no such possibility, to paved areas within plot boundaries.

As laid down in Water Law Act (Dz.U. 2017 Poz. 1566, 2017 Article 1566), rainwater discharge to a closed or open sewerage system and draining areas within the administrative borders of cities is a water service. Environmental fees are also included in the service. Fees for discharging rainwater to a sewerage system is a different matter – it is a service fee (regulated by tariffs). The change of the legislation in the year 2017 allowed for rainwater management but, at the same time, hindered the collection of service fees for discharging rainwater to a sewerage system. Previously, sewage tariffs for resi-

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dents included this fee. According to the current interpretation, we can doubt whether such a charge can be levied. The Municipal Government Act (Dz.U. 1990, poz. 95, 1995, art. 7.1 pkt.3, Article 95, year 1995, Article 7.1, item 3) includes a list of the most important municipalities' tasks. "To meet the collective needs of the community is one of the municipalities' own tasks. In particular, the own tasks shall include: […] water supply, sewerage disposal and treatment of municipal wastewater, maintenance of cleanliness and order and sanitation, landfill and disposal of municipal waste, electricity and heat supply, and gas". It is worth noting that the above does not constitute a fixed catalogue. However, there is no reference made to rainwater management. A debate concerning this provision is centered around a question whether rainwater management is an example of meeting the collective needs of the community, or not. An answer to this question determines whether utility fees for discharging rainwater and snowmelt can be charged or not. Another method for the settlement of service fees is signing civil law contracts with entities that discharge water. As of the year 2020, service fees fluctuated between 1,6 and 5,7 PLN/m^3. Only three *gminas* have introduced clear discounts when rainwater is subject to retention (Godyń, 2020, p. 107). In Poland, about 40 cities have introduced service fees for discharging rainwater [Consultation on fees for rainwater, 2021 Report on the completion of project team's work dated 19 February 2021) (In Poland there are 2477 *gminas*, including 302 urban *gminas* (Polish: *gmina miejska*), 662 urban-rural *gminas* (Polish: *gmina miejsko-wiejska*) and 1513 rural *gminas* (Polish: *gmina wiejska*)].

In reality, Poland's *gminas* deal with rainwater management on their own or entrust the task to their own entity (budgetary establishments, or urban companies) or procure it to a private entity for infrastructure maintenance. A small share of *gminas* apply fees for discharging rainwater to a sewer system; most of them use their budget to cover the costs. In many *gminas*, especially the smaller ones, infrastructure for discharging water has never been inventoried, as in Poland such infrastructure can be owned by private entities.

We must note that tariffs for water supply and sewerage collection are adopted by the Council of *Gmina* and accepted by Polish Waters[1]. Rainwater fees in a combined system are settled in a sewerage tariff (which some question as unlawful) and service fees for draining rainwater to a sewerage sys-

1 The State Water Holding Polish Waters is the main entity responsible for water management in Poland (since 1st January 2018). Polish Waters have ownership rights to waters that are the property of the State Treasury. It charges water service fees, issues administrative decisions (water legal permits). Polish Waters is also a regulatory body responsible for ensuring protection of residents against unjustified increased fees for water and sewerage. It is a market regulator.

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tem are adopted by the resolution of the Council of *Gmina.* The fees are not approved by the market regulator.

We must also note that, in Poland's cities, many different entities are involved in rainwater management; the number of those entities fluctuate between 6 and more than 10, which hinders the coordination of implemented tasks.

To sum up, the legal situation concerning rainwater management in urbanised areas is not precise enough.

Results of the research

The analysis has helped to identify three main organisational-financial operator models for rainwater management in Poland. What distinguishes the identified models are financing and infrastructure ownership (Table 4). It is important whether it is the end user that pays service fees for discharging rainwater to a sewerage system, or whether the *gmina* budget covers them fully, as it can have a significant financial impact. When a *gmina* pays for, or subsidises the services provided by an operator, it is crucial to assess how the budget and settlement rates (fixed or variable) are defined. It is also important to determine who carries out infrastructure investment and whose budget is burdened with debt (which, in its turn, influences the capacity of a local government and an operator to contract debts).

The operator-public model (Table 4, Figure 5) is based on public financing, there are no fees for discharging rainwater charged to the end user; the city owns the infrastructure and the investment (which involves obtaining subsidies). There is an operator, a subsidiary company of the city itself (a water company). The city deals with all water issues, except for the issues controlled by Polish Waters and the ones handled by a water-sewage company. The City of Gdańsk has developed such a model.

The operator-market model has been developed in the city of Poznań (Table 4, Figure 6) and is relatively the latest of all the models described in this article. There is a water-sewerage company which is owned by local government units that this company operates. This company sets up a daughter company responsible for the tasks related to rainwater management. Infrastructure ownership remains in the hands of the local government, although a part of a closed sewerage system is leased from the city, so that the company can carry out the entrusted tasks. The residents pay fees for discharging rainwater under civil law contracts. The city pays for draining its properties. The company obtains funds for investment. Another entity deals with the implementation of BGI.

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Table 4. Characteristics of operator models for rainwater and snowmelt management in Poland's big cities

Criteria / Model type	Operator-public Model The City of Gdańsk	Operator-market Model The City of Poznań	Operator-ownership Model The City of Bydgoszcz1
Constitutive features	Financing the operator is based on a compensation from the municipality's city budget	Financing the operator is based on fees from users	Financing the operator/ infrastructure owner is based on fees from users
Infrastructure ownership	Local government	Local government	Operator
Legal basis	Entrusting the municipality's own task	Entrusting the municipality's own task	Entrusting the municipality's own task
	Public agreement or in-house	Lease or loan agreement	Contribution of assets in-kind or by sale / long-term financing agreement
Service fee rates	-	City Council Resolution	City Council Resolution
Settlement with users	-	A service agreement with the operator	A service agreement with the operator
	-	Fees related to the exploitation of the city's infrastructure	Fees related to the exploitation of the city's water discharge infrastructure and its development or maintenance (deprecation)
Settlement between an operator and a local government	Agreement (a company) based on an investment and maintenance plan or a budget plan and its execution (a budget unit)	Investment lease payment to the municipality; optionally subsidising the operator, if fees from users do not cover the costs	The municipality's payments for draining its properties based on parameterised criteria; optionally subsidising the operator, if fees from users do not cover the costs
Investments	Local government	Local government	Operator
Foreign subsidies	Local government	Local government	Operator
Assets generated in the investment process	Balance sheet of a local government	Balance sheet of a local government unit	Balance sheet of a company
Examples	Figure 3.1	Figure 3.2	Figure 3.3

Source: author's work based on Sumisławski (2021).

The third model is called the operator-ownership model (Table 4, Figure 7) because, in this case, infrastructure has been inventoried and contributed in-kind to a water-sewerage company. The company settles with the city under parameterised indicators, but a subsidy is possible, if the residents' fees do not cover the cost of system service. The job of the company is to invest and develop, as well as provide financing for investment. The debt does not impact the city's credit rating. It is an interesting fact that the residents have received a several years' exemption from fees for discharging

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Figure 5. Operator-public Model – the City of Gdańsk

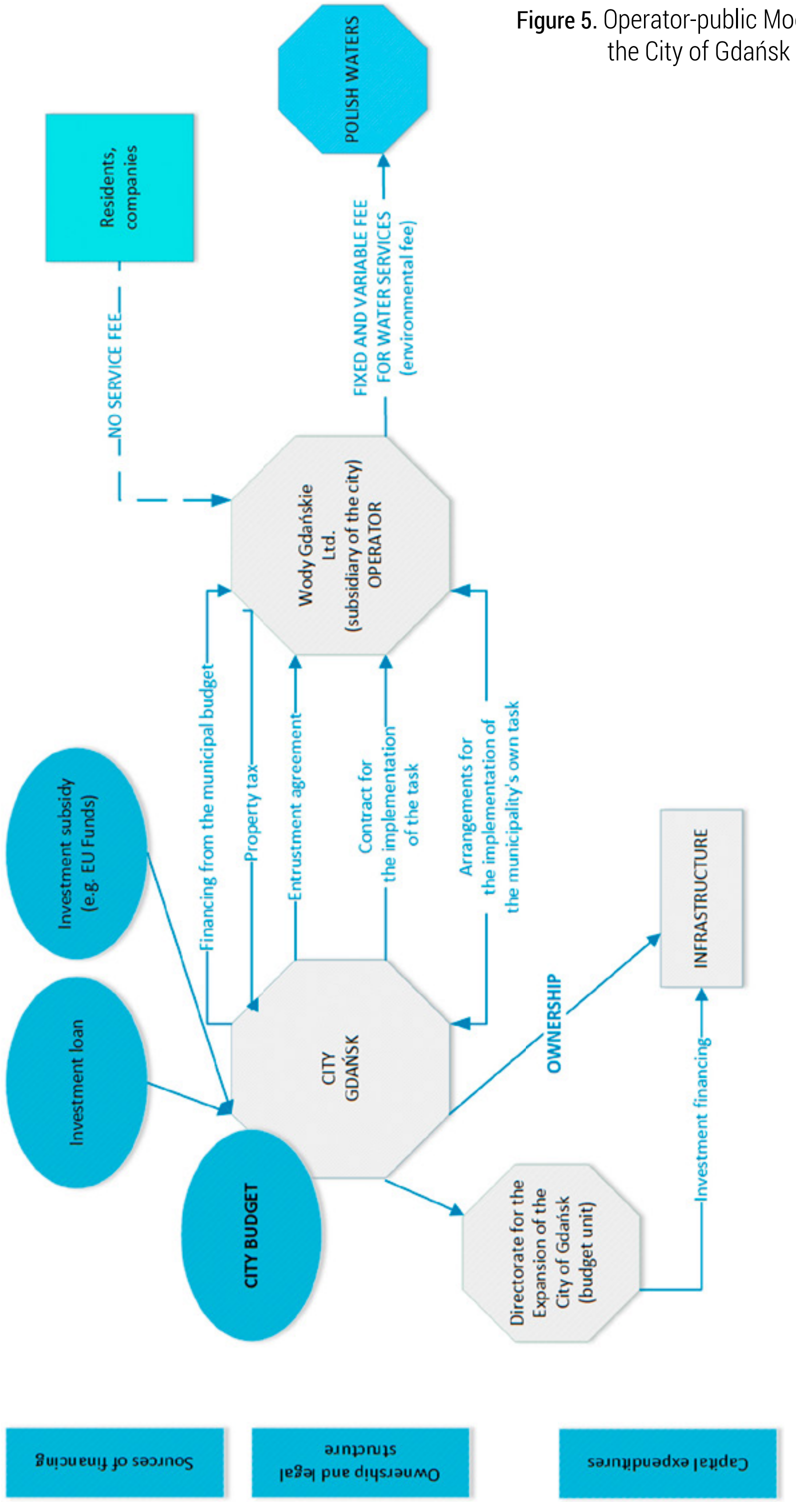

Figure 6. Operator-market Model – the City of Poznan

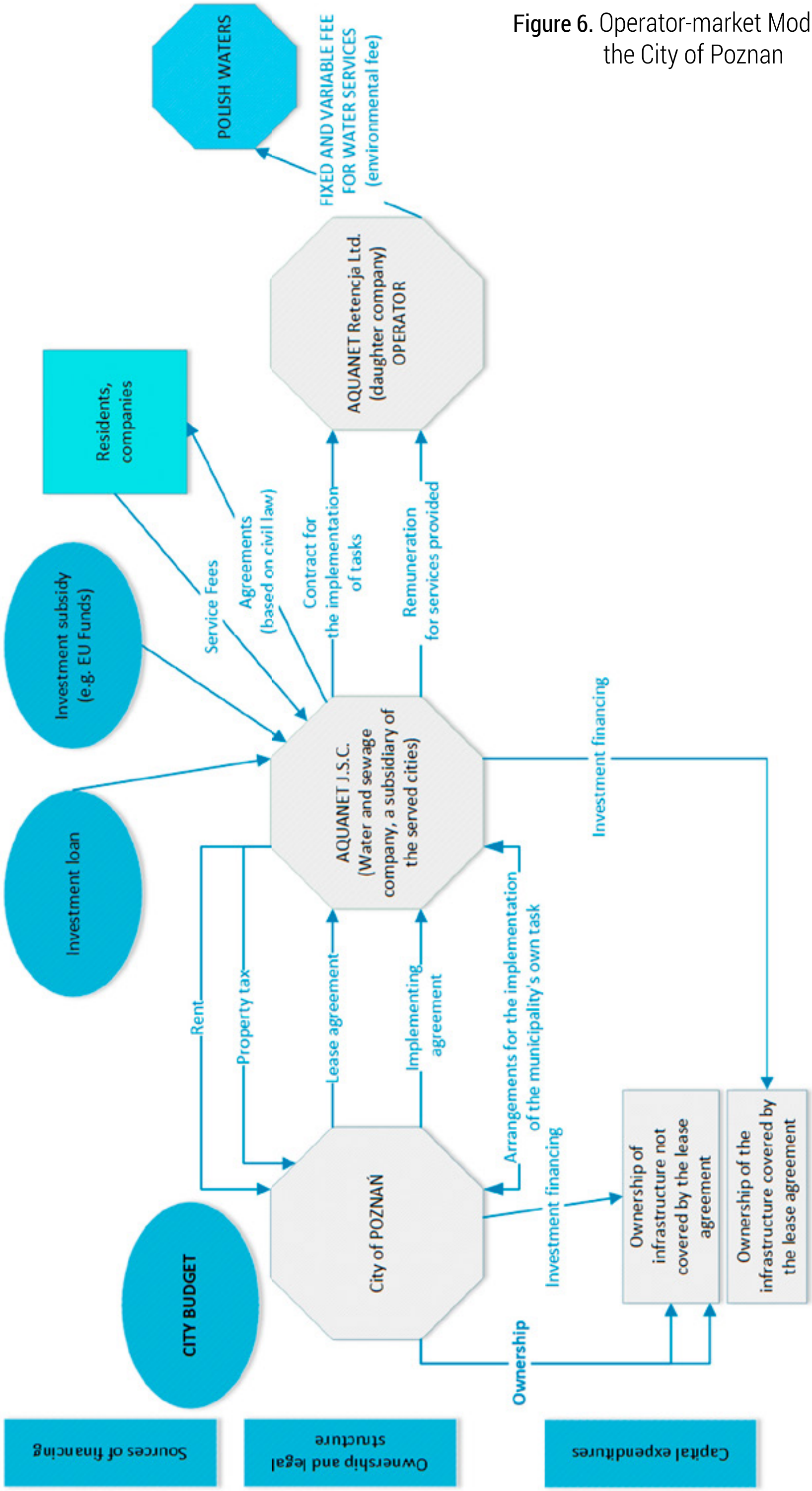

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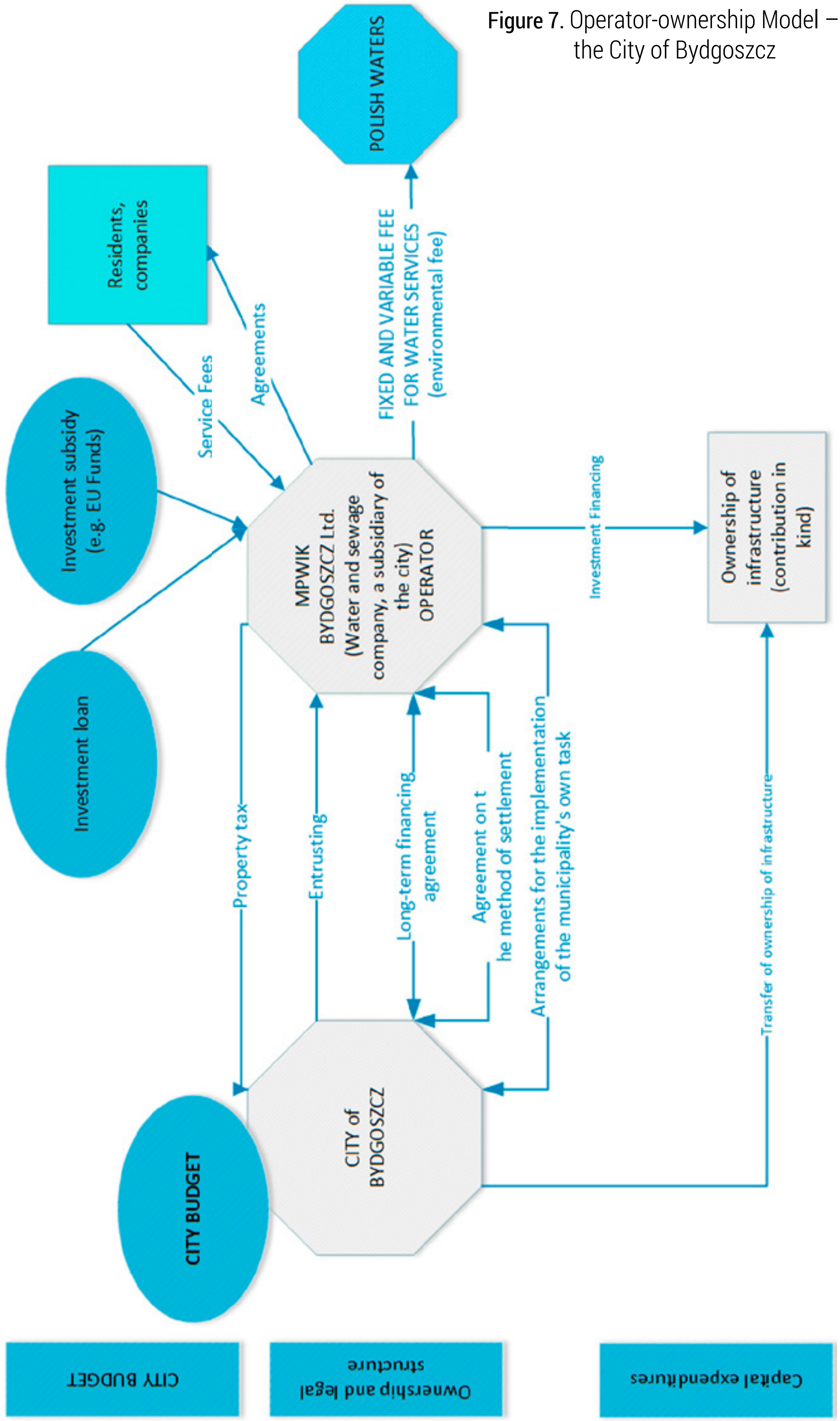
Figure 7. Operator-ownership Model – the City of Bydgoszcz



rainwater to a sewerage system, to give the residents time for the installation of retention systems. This way, they will not have to pay the fees in the future. However, few residents have made the effort.

We must note that this study considers only the most important institutions and the relationships between them. In each of the cities, there are other institutions which are also involved in rainwater management. They remain in the structure of the city or are city-dependent entities such as *Green Spaces Management (Polish: Zarząd Zieleni Miejskiej) and sometimes Urban Forests Management*, Cemetery Management, Sports Infrastructure Management. Entities not dependent on the city may also be relevant, for example State Forests. Each of these entities is involved in rainwater management and can implement blue-grey infrastructure.

Poland's legislation, for a long time, has defined rainwater as wastewater and the main task related to its management was to quickly discharge it from a city. For two decades the situation has been changing and big cities, in particular, take actions to rationalise rainwater management. It is possible now due to the provisions which changed the definition of rainwater and defined the conditions under which it becomes wastewater. However, the provisions are not coherent and many issues remain unregulated or allow for multiple interpretations. Moreover, Poland's cities struggle with sub-urbanisation and the density of development, which results in excess surface sealing. It, in its turn, increases the risk of flooding, especially flash floods (Walczykiewicz & Skonieczna, 2020). Over the last few years, however, urban adaptation to climate change has generated more interest in rainwater management.

There are no specific provisions implying how rainwater management should be handled in Polish *gminas*. However, *gmina*s especially exposed to the risk of flash flood due to their landscape (such as Gdańsk) have started to take measures to change their urban water resources management, including urban rainwater. It is an announcement of significant changes. Consequently, various ownership-financial models for urban rainwater management have developed in Poland. This study focuses on the cities where the task of rainwater management was entrusted to the operator. The study has helped to identify three models of dependency between the city and the operator. Other entities affecting urban rainwater management are not included in the study. The focus was on financial flows and organisational aspects, ownership and responsibility. At the same time, the study concentrates on integrated urban resources management and accesses the identified models in this respect.

The three identified models: the operator-public model, the operator-market model, the operator-ownership model have been characterised and their „mapping" has been attempted (Figures 5-7). However, we must also consider the strengths and weaknesses of the models (Table 5). A signif-

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icant advantage of the operator-public model (the City of Gdańsk) is the fact that most tasks regarding urban water are entrusted to one entity. The operator's dependency on the city allows for fast communication and for the city's control over ongoing tasks. However, the total financial dependency on the city's budget may impede tasks regarding rainwater management in case the city's spending is cut. At the same time, bigger investments are implemented outside the entity and they leave the city's budget with debt burden. Still, the biggest disadvantage of the model seems to be the fact there are no fees for discharging rainwater to a sewerage system. Such a fee should be an incentive for rainwater management in the user's own area. The disadvantage can be eliminated provided the provisions are improved. A water-sewerage company is still in charge of an urban sewerage system, which hinders the integration of the whole system. Infrastructure ownership remains in the hands of the local government.

Table 5. Disadvantages and advantages of rainwater management operator models in Poland

Advantages	Disadvantages
Operator- public Model (the City of Gdańsk) – Figure 5	
All tasks regarding water in the municipality, rainwater and BGI under one entity (excluding the ones managed by Polish Waters) „fast" municipality-company communication Extensive educational action	100% financed by the budget of a local government No fees for rainwater management Bigger investment in another municipality's unit Foreign funds obtained mostly by the municipality, not by the company
Operator-market Model (the City of Poznań) – Figure 6	
A separate entity – transparent financing, prevention of cross- subsidation Fees for draining rainwater Possibility of foreign funds for investment with no burden on the municipality's budget Infrastructure remains the municipality's property (investments)	Only part of rainwater infrastructure under the company's management (closed drain system) The Council of the City sets fees, they may not cover the costs Infrastructure remains the municipality's property (investments) Another entity deals with BGI
Operator-ownership Model (the City of Bydgoszcz) – Figure 7	
Infrastructure transferred to the water-sewerage company (investment and maintenance in one hand), correctly calculated depreciation Settlement with the municipality on the basis of parameterised criteria Long-term agreement with the municipality Fees for rainwater discharge Investments do not directly burden the municipality's budget Extensive educational action	Potential risk that, in such a big entity, rainwater and BGI issues will be set The Council of the City sets fees, they may not cover the costs

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The operator-market model developed in the City of Poznań is assumed to provide transparency in financing rainwater management and to prevent cross-subsidation. At the same time, it moves away from integrated urban rainwater management as, by definition, a closed sewerage system is managed by a different entity than an open sewerage system. Still, infrastructure ownership remains in the hands of the local government.

The operator-ownership model developed in the city of Bydgoszcz is based on contribution of infrastructure ownership to the operator in kind (in this case a water-sewerage company). Such a solution requires full inventory and quoting of infrastructure for discharging water. This solution works well for the city of Bydgoszcz. However, its weakness is the fact that rainwater issues are included in the range of activities of a relatively big entity. The experience proves that they might end up being marginalised.

Commonly in Poland, a road administrator is in charge of tasks regarding rainwater management. Then, it is part of „business as usual" and the focus is on water discharge, and not on the implementation of modern, nature-based solutions.

These considerations should indicate the best model for rainwater management. However, it is not possible for certain reasons. One of the reasons is the fact that the analysis do not include complicated issues connected with tax returns, which may influence the effectiveness of the system. Even if we use an effectiveness criterion (Rosiek, 2008), the assessment of effectiveness should be based on measurable indicators, which is not possible in this case. Firstly, because the data is not collected in a coherent and precise way. Secondly, the implementation of specific solutions is connected with organisational culture in a given city.

The results of the conducted survey show organisational culture is of great significance for the development of modern water management models and, whenever cooperation between entities is well-organised and successful, a legal-organisational form is of secondary significance. This makes the models sensitive to human factors.

The possibility to apply fees influences the effectiveness of rainwater management in Poland, but not its efficiency. There are a number of possible explanations which, however, require further analysis. Among possible explanations, we could mention the lack of nationwide requirements (regulations) in the area of fees for surface sealing / retention loss (currently existing fees are facade fees), and municipalities' inability to prove the actual water retention levels allows for discounts on ecological fees for discharging rainwater […] according to the Water Law Act.

Conclusions

Water management, especially rainwater management in urbanised areas, appears to be the primary challenge of the climate transformation age. Despite imprecise legal provisions, many of Poland's cities--especially these exposed to the effects of river floods or flash floods--have started to implement organisational-legal changes with the purpose of finding the appropriate model for rainwater management in their area. It is a model which will reduce flood risk and drought effects while making it possible to finance this task.

The study focuses on models developed in Polish cities which use the affiliated operator for the implementation of the task. The study also focuses on formal-legal and financial issues of that relationship. However, no complete analysis on tax effects has been carried out, which should be the subject of further analysis.

On the basis of the study, we can conclude what follows:

- A literature review on the subject leads to a conclusion that integrated urban rainwater management is a direction described as the most promising;
- Integrated management process should include not only rainwater, but all kinds of non-potable waters, including grey and re-used;
- Legal framework, norms and standards for water reuse and water quality adapted to the users' needs are essential;
- The development of information ecosystem is required. It will integrate resources of all institutions and will be available to all water users;
- Despite the statutory change of rainwater definition in Poland (i.e. rainwater is not wastewater), a number of specific provisions have not been adopted, which causes chaos and hinders the implementation of reasonable solutions that would stimulate proper urban rainwater management, including economic instruments (fees, taxes);
- There are a lot of entities involved in urban water management (including rainwater management) which hinders the implementation of harmonised tasks, even with full cooperation between the entities;
- Three main operator models for rainwater management have been identified in Poland, their constitutive features being: infrastructure ownership and financing of ongoing tasks and investments;
- Identification of weaknesses and strengths of operator models for rainwater management is of significance in the context of their implementation in other cities in Poland;
- A determining factor is the issue of transferring infrastructure ownership to the operator;

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- Accepted coordination models for rainwater management influence the implementation of integrated urban water management, including rainwater; the competences for managing different types of drainage infrastructure are divided among different institutions, which may hinder the implementation of integrated urban water management;
- Poland's cities that want to implement or improve their rainwater management system are in a difficult situation, because of imprecise legal framework.

To conclude, we must note that the study outlines further research challenges, connected especially with models for water management in smaller cities not influenced by a nearby metropolis and with society's approach to fees for rainwater management.

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