Analysis of Water Retention Possibilities Based on Programs, Strategies and Selected Projects in Poland

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Abstract. A particularly important and topical issue in contemporary urban planning and urban design is to prevent the current climate threat. The scale of the problem and the forecast of the effects of climate change are shown in the publication of numerous research centers such as NASA and the IPCC. The Report of a temperature increase of 1.5 degrees relative to the pre-industrial era has shaken public opinion, however, a less optimistic scenario assumes an increase of 3 degrees. Local governments often face the challenge of rapid and effective response to the effects of climate change. Adaptation strategies to climate change have been developed at the EU level since 2009, in which the so-called White Paper has been passed, recognized as one of the first documents to define goals and measures, and on the national (Polish) level from around 2010. On the basis of strategic documents and research of scientific institutions, many local government units adopt programs aimed at implementing specific solutions. In the light of climate reports, it turns out that one of the most sensitive areas to climate change is water management. Therefore, effective adaptation measures include those aimed at rational management of rainwater. As a result, there are created comprehensive adaptation programs focusing on various sectors of the economy. Some of them are based on elements such as: green infrastructure, support for biodiversity or the implementation of activities in the field of blue-green infrastructure and the idea of "sponge city". They have been analyzed by the authors in terms of their usefulness and compliance with higher level documents. The aim of the study was to look at what actions are undertaken by cities in order to implement adaptation postulates. Selected activities undertaken by local government units of the cities of Olsztyn, Bydgoszcz and Gdańsk were analyzed. For educational purposes there are prepared information brochures for investors, residents and officials. They present the available tools and methods for sustainable rainwater management and increasing the city's resilience to the effects of climate change by increasing retention based on natural-based solutions. Equally important are the projects themselves, which is why another objective of the research was to analyze the implementation for compliance with the stated goal of increasing the retained water and adaptation to climate change of the city. The research methodology is based on desk-research and indirect inventory. A representative example of the research carried out is the implementation of the programs: "Rainwater management systems in the city of Olsztyn" and "Expansion of the rainwater management system in the city of Olsztyn". The authors conclude that the adopted programs and strategies, as well as the implemented investments, are examples of both beneficial measures to improve water retention in the city, but unfortunately, they are also examples of "tools" to raise funds for investments, there are many in which rainwater is treated as sewage and still go directly to the sewage system.
1. Introduction

Water retention is the ability to retain water that occurs due to rainfall. The existing rivers and lakes have a natural retention, but in the case of Poland it is definitely too small in relation to the needs of the country. It is estimated that the proper one should be not less than 25% of all rainfall. Meanwhile, the current retention in Poland is at best 6%. This means that as much as 94% of rainwater is supplied to rivers and hence the water flows into the Baltic Sea, where it becomes salty forever. According to statistical data, the annual water resources amount to 1.4 dam3 per capita, while in most European Union countries freshwater resources amount to 5 dam3 per capita [1]. This places Poland practically in the last place in Europe in terms of water resources per capita. This is a value comparable to the conditions prevailing in Egypt. These data include both: macroretention, in other words hydrological, understood as resources of rivers, large dam reservoirs and lakes, and micro retention, that is, one that relates to the possibility of "storage" in the field, mainly in the ground. The macro and micro retention possibilities are related to each other. The high level of surface waters results in a high, favorable level of groundwater from which at an adequate height the surface layer can be supplied. In Poland, the situation is definitely unfavorable for both macro- and microretention [2].

Since around 2010, the government of the Republic of Poland, in accordance with the recommendations of EU institutions, has been introducing micro-retention programs, which are successesively implemented in Polish cities. Therefore, questions arise - how are these programs implemented and can the manner of implementation inspire optimism in the light of existing needs? Is building dry flood protection reservoirs, which accumulated water during high states, which threaten floods, and is emptied after the threat has passed? Does it seem obvious that systems of surface water reservoirs should be implemented, starting with large ones and ending with small in the field ones? It is a process as complex as it is costly. It particularly concerns the problem of microretention, which is related to the water capacity of soils and depends on many factors. Improving the soil structure so that it can affect water capacity is a long, complicated process that requires many agrotechnical treatments.

According to D. Wróblewska, EU, national, regional and local strategies are based on two types of actions: mitigation of changes and adaptation to changes [3]. However, more and more attention is now focused on adaptation, the mitigation strategy is relegated to the background, because countering the negative effects of human activity in the current situation is no longer sufficient. Adaptation to climate change is the most appropriate approach nowadays [4]. Water saving can be introduced at many levels. On a household scale, changing habits and investing in appliances that use less water can have positive results1. A special role in the field of climate action, including investments in blue and green infrastructure (BGI), is assigned to urban planning due to its long-term focus on results and interdisciplinary action [4].

2. Description and scope of the study

On the basis of strategic documents and research of scientific institutions, many local government units adopt programs aimed at implementing specific solutions. In the light of climate reports, it turns out that one of the most sensitive areas to climate change is water management. Therefore, effective adaptation measures include those aimed at rational management of rainwater. As a result, comprehensive adaptation programs focusing on various sectors of the economy are created. Some of them are based on elements such as: green infrastructure, support for biodiversity or the

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1 For example, when using a shower, about 180 liters of water are used for 10 minutes, while only 60 liters during 4 minutes. Ecological washing machine uses approx. 43% less water during one cycle than the standard washing machine. In the scale of a residential building, gray water installations or any water retention systems that improve the microclimate and the quality of the external space, such as rain gardens, absorptive basins, rainwater storage tanks from roofs, can be used. Research conducted on one of the Polish housing estates in Krakow shows that investment in green infrastructure elements that reduce surface runoff 3 times with rainwater charges of EUR 1.00 / m3 would pay off within 12 years [5].
implementation of activities in the field of blue-green infrastructure and the idea of "sponge city". Most often they are developed for entire units within their administrative boundaries and refer to planning documents. Therefore, these documents have been analyzed by the Authors in terms of their suitability for the prevention of climate change and compliance with higher level documents. This forced the chronology of research, which began with a review of executive documents adopted at the European level, through national, and ending with local. Local ones, as the most important ones, in the description of the research, represent selected activities undertaken by local government units of the cities of Olsztyn, Bydgoszcz and Gdańsk. The aim of the research was to look at what actions are undertaken by cities in order to implement adaptation postulates. In the field of education, information brochures are prepared for investors, residents and officials. They present the available tools and methods for sustainable rainwater management and increasing the city's resilience to the effects of climate change by increasing retention based on natural-based solutions. The implementations themselves are equally important, therefore the next goal of the research was to analyze the implementation in terms of compliance with the stated goal of increasing the retained water and adapting the city to climate change. The research methodology is based on desk-research and indirect inventory.

3. White Paper, the beginning of adaptation strategies in European countries
The document commencing adaptation activities in European countries is the so-called White Paper (Adaptation to Climate Change: A European Framework for Action) adopted in 2009. The document emphasizes the important role of spatial planning in terms of long-term and strategic approach, due to the fact that urban centers are particularly vulnerable to climate change. In addition, extreme phenomena hit infrastructure such as buildings, transport, energy and water supplies. Another problem is the process of ecosystem disappearance, which will result in a reduction in the adaptability of cities. It is recognized in the challenges facing policymakers that green infrastructure can play a fundamental role in the adaptation process [6]. Mainly because it provides vital resources for social and economic reasons in extreme climatic conditions. The section on improving the adaptability of biodiversity, ecosystems and water sets out activities that include exploring the possibilities and taking action to increase the water storage capacity of ecosystems.

4. Polish strategies on a national scale
4.1. Published forecasts
Floods or droughts are extreme phenomena that occur more frequently and more intensively today, which raises concerns not only of scientists, but also of local authorities. The increase in precipitation is closely related to the increase in air temperature. Higher temperature air contains more water vapor, resulting in an increase in rainfall of approximately 7%/1°C. As the temperature rises, evaporation increases. According to physical law, evaporation and precipitation balance each other over longer periods, which means an overall increase in precipitation. Unfortunately, this will not increase the country's water resources [7]. The Institute of Meteorology and Water Management informs about the hydrological situation in Poland. According to them, the hydrological year 2019 differed both in meteorological and hydrological terms from the average conditions. Only the values of precipitation during 4 months in the period from November 2018 to October 2019 were normal (February, March, August, October) [8]. Higher temperature is also associated with an increase in evaporation from the soil (evapotranspiration), more rainfall is needed to maintain a convenient soil moistening, 15% increase for every 1°C. It should also be mentioned that rainfall is characterized by periodic occurrence. Soil is exposed to the risk of losing its structure due to excessive drying in hot weather, which causes it to lose its absorbent properties and is washed away with rainfall [7].

2 As part of the article, the authors reviewed from the point of view of sustainable rainwater management.
3 During 4 months (November, April, June, July) values below the norm were recorded, and during 4 months values of approx. 150% of the norm were recorded (December, January, May, September).
The Polish Institute of Soil Science and Plant Cultivation (IUNG-PIB) found the occurrence of agricultural drought in Poland in all 14 reporting periods. For the phenomenon of drought, the concept of the climatic water balance (CWB) is important, it is the difference between revenues in the form of precipitation and losses, i.e. evapotranspiration. CWB in the months particularly prone to drought, i.e. in the 5th reporting period (1.05-30.06), was negative and amounted to -87mm, in the 6th reporting period (1.06-31.07) it was -173mm, only on 1.08-30.09 the situation improved -20mm, which, however, did not exclude the occurrence of agricultural drought [9]. This means that more water evaporates from the surface of the earth than it falls as rain. This proves how important it is to increase retention.

4.2. Overview of government programs
In 2010, Poland adopted a position on the White Paper, in which it was decided to develop an adaptation strategy for sectors and areas sensitive to climate change. In 2013, the Strategic Adaptation Plan for sectors and areas sensitive to climate change by 2020 with a perspective by 2030 was adopted by the Ministry of the Environment. Water management is defined in the document as a sector sensitive to climate change. Climate change scenarios for Poland were developed thanks to the KLIMADA project, under which expert opinions were developed to illustrate the expected climate changes. The probable climatic conditions were based on simulations of hydrodynamic models of the atmosphere and the ocean. It is also the first attempt to define a long-term vision of climate change by 2070. Analyzes show that the frequency of flash floods will increase. The priority action is to reform water management structures, taking into account adaptation to climate change. Also objective 6 concerning shaping social attitudes is given as a priority action to education and increasing awareness of, among others, the need to save resources, especially water [10]. The next step taken by the Ministry of the Environment is the decision to prepare urban adaptation plans for 44 largest urban centers in Poland. Due to the scale of the project, it is a pioneering activity not only in Poland, but also in Europe. 44 cities joined the project, most of them have over 100,000 inhabitants [11]. In Poland, the most important planning document on a national scale is the National Spatial Development Concept 2030. In terms of water management, there are provisions on protection against flood hazards, but there are no provisions that would suggest that it would be done in a sustainable manner [12]. The document at the voivodeship level is the National Strategy for Regional Development. It defines the most important challenges of regional policy. The main challenge is to adapt to climate change and to reduce environmental risks. Objective 1 includes the provision of measures to protect and improve the condition of the environment, including adaptation / adaptation to climate change. The provisions are still very general and burdened with a certain amount of understatement [13]. Positive changes are brought about by the provisions of the National Urban Policy until 2023. The point of environmental protection and adaptation to climate change draws attention to the problem of the urban heat island and the increased occurrence of flash floods in urban areas. The document emphasizes the key role of local governments as the governing bodies of the city center. Their activities should be based on blue and green infrastructure. The document also emphasizes that the subject of adaptation is one of the most important challenges for EU countries [14]. The Strategy for Energy Security and Environment 2020 is important from the point of view of water management. Action 8, which is the implementation of evaluation mechanisms for ecosystem services for the water management sector, deserves attention. Where it has rightly been noted that system services are neglected in the valuation of investment costs. Measure 9, i.e. adapting the water management sector to climate change, which involves increasing water retention. It was also emphasized that adaptation measures not only include the construction of the necessary infrastructure, but also a number of coordinating, educational and information measures. It is an important definition of undertaking adaptation and specifying the essence of water management in the country.

The effects of the increase in urbanization and the increasing degree of surface sealing, and hence increased surface runoff and, consequently, the disturbance of the stormwater management system are not really of interest to higher-level planning documents. Responsibility was transferred to the local...
authorities of individual urban centers. What is new are the adaptation plans for 44 cities. It is an attempt to prioritize activities. The chosen strategy of analyzing the threats and potential of each city is to result in a thorough analysis and appropriate solutions adequate to the current state. Perhaps the documents require more in-depth analysis. It is too early to draw conclusions as to whether this is the most appropriate plan of action. The authors believe that the topic definitely requires in-depth research, which cannot be presented in the article.

5. Awareness-raising activities
Recently, a lot of publicly available and free publications on blue and green infrastructure (BGI) and retention have been created. Local governments see potential in BGI investments. They are aimed at increasing social awareness and acceptance of this type of practice. Shaping the awareness of the society is a long-term process and is associated with many educational undertakings. In the light of scientific research, these actions make sense, because a society aware of the problem is a society acting for the good of the planet. The guides were created, among others, in Warsaw, Kraków, Bydgoszcz, Wrocław and Gdańsk. Their content concerns various elements of BZI, including surface retention reservoirs (figure 1), also with a recreation area (figure 2) or rain gardens (figure 3).

Figure 1. Dąbski pond at the Plaza Gallery, Kraków. Photo: Paulina Gama Marques.

Figure 2. Retention reservoir with a recreation area, Park Lotników, Kraków. Photo: Paulina Gama Marques.

Figure 3. Rain garden in estate Teatralne, Kraków. Photo: Paulina Gama Marques.
The Sędzimir Foundation has been operating in Warsaw for years, which deals with the promotion of sustainable development and increasing social awareness in this topic\(^4\). In Wrocław, at the request of the Commune, scientists of the University of Life Sciences worked on a *Catalog of Good Practices*, which contains information on how to sustainably manage rainwater from road lanes\(^5\). As part of the research, the authors looked at guidebooks from Bydgoszcz and Gdańsk.

5.1. Bydgoszcz “Catalog of green and blue infrastructure. Part II. Guidelines and solutions”.

Due to the problems with floods\(^6\), Bydgoszcz is very active, also in the field of education and promotion of good solutions. The company Municipal Water Supply and Sewerage in Bydgoszcz is implementing the project *Rain is profit* (*pl*: *Deszcz to zysk*). The program accompanies the project, *Construction and reconstruction of the rainwater sewage system and adaptation of the rainwater sewage system to climate changes in the city of Bydgoszcz*. An information brochure, *The Green and Blue Infrastructure Catalog*, has been developed. *Part II. Guidelines and solutions*\(^7\) [16]. The catalog is intended for planners, town planners, architects, employees of city departments, investors and private persons. The mission of this catalog is education and emphasizing the shared responsibility for the quality of life in Bydgoszcz. The catalog offers 20 solutions and 6 areas of application: squares and parks, roads, parks, housing estates, compact buildings, single-family houses. All 20 ideas can be applied in a housing estate, most of them in other areas. The cards have been developed: permeable surfaces, local depressions with bioretention, drainage channels, absorptive ditches, absorbent troughs, revitalization of urban watercourses, rainwater at the house, rain gardens, plant passages, hydrophyte ponds, surface infiltration and retention tanks, infiltration basins, underground reservoirs watertight, surface watertight retention reservoirs, drainage boxes, root boxes, green and blue roofs, fountains with retention, water squares, biomimetics (imitation of water). Each solution is developed in a very transparent way. Information is included on use, maintenance and what you should pay attention to. A very important point is to define the conditions of implementation, which have been classified into 5 categories: infiltration, topographic, construction, formal and general. However, it should be noted that the descriptions are fairly general and do not contain detailed specifications. At the end there is a practical table, where on a scale of 1-5, the level of pre-cleaning, infiltration, retention, costs and maintenance is determined. Each example is also presented in the form of a diagram along with the determination of the subsoil layers and individual elements of the structure. However, individual layers and elements have not been dimensioned, which may raise many questions on the part of the interested person. Bydgoszcz also uses a financial incentive towards its residents. Pursuant to Resolution No. XVIII / 418/19 of the Bydgoszcz City Council of November 27, 2019, the rates for the discharge of rainwater or snowmelt were established. 4.44 PLN/m\(^3\) net in 2021. The fee applies to water from hardened, sealed surfaces. On the other hand, the areas where the waters are developed within the property and are not discharged into the sewage system are not included in these fees.

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\(^4\) As part of their activities, publications on rainwater management, strategic tools at our disposal in Poland and abroad, catalogs of technical solutions for blue-green infrastructure, rain gardens and increasing retention were created.

\(^5\) The authors note that as a result of progressive urbanization, the surface is excessively sealed. The publication is very extensive, it contains 19 cards with solutions presenting all technical and theoretical aspects of implementation. Importantly, the catalog is also enriched with theoretical knowledge including legal regulations, plant species, indicators determining, among others, retention capacity, restoration costs, nuisance to exploitation and water treatment plants.

\(^6\) European standards define the frequency of floods. For built-up areas, a flood may occur once every 20 years, and in service and industrial areas - once every 30 years. Bydgoszcz struggles with the problem of frequent flooding. According to the city data, as many as 75 km of streets and 18% of buildings are at risk of flooding more often than specified in the standards [15].

\(^7\) The prerequisites for work on the guide are the 5th IPCC report, the Strategic Adaptation Plan to climate change 2020 (SPA 2020) and the Water Law adopted in 2017.
5.2. Gdańsk "The rain garden in 5 steps" [17]

Gdańsk distinguishes 5 main directions that make up the blue and green infrastructure that supports adaptation to climate change: street retention, urban greenery, household retention, field retention and reservoir retention. As part of the guide, the developed material concerns rain gardens, which can be used both as an element of home and city retention. The purpose of the guide is to show residents how to install such a garden in 5 simple and well-described steps. Due to the fact that it is a very simple solution, not expensive, but very effective, the city wants more and more such investments. At the beginning, the benefits of building a rain garden were mentioned. The rain garden collects water from nearby surfaces, is characterized by the selection of appropriate hydrophilic plants that purify the water, improve biodiversity and have a positive effect on the aesthetics and perception of the site.

According to the guide, an important advantage is the ability to combine gardens into an extensive small retention system. As the rain garden is the place where water is collected from the roof, in the first step it was described how to calculate the roof area from which water will be drained. The second step was devoted to the types of substrate. To make a garden in the ground, a permeable substrate is needed, otherwise it remains to make a rain garden in a container or install additional drainage. Step 3 determines the selection of plants and materials. Not every plant is suitable for installing a rain garden. Hydrophyte plants, i.e. those that tolerate more water and have cleansing abilities, will work best. In the guide, they have been divided into 5 groups: drought-promoting, for planting in flooded areas, for planting in water, shrubs and trees. Information on the planting density, conditions and requirements are included for each plant. Step 4 is devoted to three types of gardens depending on the mode of operation: a garden in a permeable soil, a sealed garden in the ground and a rain garden in a container. The first garden is called "dry garden". Such a garden can be made on a permeable substrate, where water infiltration into the ground is possible. Such a garden is made directly in the ground, pay attention to the layers of the ground, as well as the slope and the connection of the downspout from the roof. If the area intended for the garden is impermeable ground or for some reason the infiltration of water is limited, you can make a sealed rain garden in the ground, the so-called "wet garden". This type of garden is characterized by the fact that the bottom is lined with a sealing layer and the excess water is drained to the rest of the garden or to the sewage system. A final example is a container garden which is a great idea for a patio and is primarily intended to receive rainwater from drain pipes. The study has been enriched with diagrams showing the cross-section of each of the gardens along with the determination of appropriate layers, slopes and distances. The diagram is presented in a technical and accessible way and contains all the necessary information needed to make a garden yourself. Step 5 concerns the care and maintenance of the finished garden. The authors emphasize that the gardens are easy to maintain and do not require much care or watering. You only need to check the technical condition of the drains, carry out mowing or trimming treatments once a year and monitor the area on an ongoing basis.

6. Realizations

The city of Olsztyn has benefited from the Infrastructure and Environment Operational Program 2014-2020 published by the Ministry of Infrastructure and Development [2]. Under priority axis II: environmental protection, including adaptation to climate change, Olsztyn implements 2 programs: 

- Stormwater management systems in the City of Olsztyn ("project 1")
- Expansion of the rainwater management system in the City of Olsztyn ("project 2").

Both projects have common goals, which include increasing the amount of water retained, adapting to climate change, and increasing the safety and resilience of the city to natural disasters and environmental monitoring.

**Stormwater management systems in the City of Olsztyn** will include the construction of three small rainwater retention reservoirs, two retention reservoirs and a rain collector, one retention reservoir and a rainwater sewage system, and the construction of a rainwater sewage network implemented under another project (Modernization and development of an integrated public transport system in Olsztyn) [18].
Table 1. Selection of output indicators for the project 1.\(^8\) [19].

| Indicator                                               | Unit of measure | Value     |
|---------------------------------------------------------|-----------------|-----------|
| The length of the constructed rainwater drainage system  | km              | 3.38      |
| Length of the rebuilt rainwater drainage system         | km              | 9.44      |
| Length of the renovated rainwater drainage system       | km              | 0.08      |
| Number of constructed devices for the management of rainwater | pcs.      | 5         |
| Number of rebuilt devices for rainwater management      | pcs.            | 1         |
| Capacity of small retention facilities                  | m\(^3\)         | 163 596   |
| Area covered by the rainwater management system         | ha              | 1 188     |

| Direct result indicator                                 |                 |           |
|---------------------------------------------------------|-----------------|-----------|
| Volume of water retained                                | m\(^3\)         | 1 860     |

All built retention reservoirs were created as surface reservoirs, using the natural topography of the area. It is planned to plant lawns in three projects, and in four projects it is planned to plant not only grass, but also trees, shrubs and flower beds. Two reservoirs are also to serve recreational purposes.

As part of project 2, construction of three rainwater drainage networks and reconstruction of three rainwater drainage networks, drainage of the area of the Construction School Complex, reconstruction of drainage and reconstruction of one storage reservoir are planned. The rest of the tasks: the construction of retention reservoirs and the four times reconstruction of the rainwater sewage system is carried out under five other projects that involve the construction or reconstruction of engineering structures, i.e. roads, streets, bridges [20].

Table 2. Selection of output indicators for the project 2\(^9\) [21].

| Indicator                                               | Unit of measure | Value     |
|---------------------------------------------------------|-----------------|-----------|
| The length of the constructed rainwater drainage system  | km              | 1.07      |
| Length of the rebuilt rainwater drainage system         | km              | 18.20     |
| Number of rebuilt devices for rainwater management      | pcs.            | 3         |
| Area covered by the rainwater management system         | ha              | 129.51    |

| Direct result indicator                                 |                 |           |
|---------------------------------------------------------|-----------------|-----------|
| Volume of water retained                                | m\(^3\)         | 42 733.44 |

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\(^8\) Based on Annex 1 - List of product and result indicators for the program "Stormwater management systems in the city of Olsztyn". Elaboration: Paulina Gama Marques.

\(^9\) Based on Annex 2 - List of product and result indicators for the program "Development of the rainwater management system in the city of Olsztyn". Elaboration: Paulina Gama Marques.
On the basis of table 1, it can be seen that the project 1 activities contribute to the city’s adaptation to climate change. This is evidenced by the value of the indicator specifying the capacity of small retention facilities. The study area is also larger than in the project 1 program and the length of the constructed or reconstructed stormwater drainage networks is shorter (table 2). Table 2 does not contain an indicator specifying the capacity of small retention facilities. P1 covers an area ten times smaller than P1 and is mainly based on a rainwater drainage system of approx. 20 km.

7. Results and discussions

7.1. Awareness-raising activities

The catalog from Bydgoszcz fulfills the role of education and the residents’ interest in colorful pictures in the best possible way. Perhaps, after looking through the catalog, someone will decide to establish, for example, a rain garden. However, the catalog cannot be treated as a ready-made recipe, but rather as information that the given solutions are feasible. Brochure from Gdańsk focuses on one specific element, the rain garden. The brochure contains, developed in an accessible language and detailed diagrams, provides all the necessary know-how for the implementation of the garden. Rarely, an attempt is made to combine BGI elements into an extensive small retention system.

7.2. Realizations

A positive aspect is the construction and modernization of surface retention reservoirs. It is very good that some of them are also a recreation area, although there could be more of them, as most of the reservoirs are located near housing estates. However, project 2 does not meet its goals of increasing the amount of water retained and adapting to climate change. It does not provide any retention enhancement elements. The relations between individual measures were also not presented in the project 1 and projects 2.

8. Conclusions

Strategic documents created at the government level provide general guidelines and open the door to further actions at lower levels. There is a clear interest in local governments in climate matters. It is very good that programs are implemented to raise the awareness of city dwellers. There are also many implementations that improve retention. However, some activities focus on improving the condition of the sewage system, which cannot be defined as climate change adaptation projects. Moreover, the actions are punctual, they do not constitute a visible system. Further implementation studies are needed to determine their effectiveness in retrospect.

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[18] Stormwater management systems in the City of Olsztyn (in polish: Systemy gospodarowania wodami opadowymi na terenie Miasta Olsztyna), [source: https://olsztyn.eu, access: 2.2021].

[19] *Appendix No. 1 - List of product and result indicators for the program "Stormwater management systems in the City of Olsztyn"* (in polish: Załącznik nr 1 - Wykaz wskaźników produktu i rezultatu dla programu “Systemy gospodarowania wodami opadowymi na terenie Miasta Olsztyna”).

[20] Development of the rainwater management system in the City of Olsztyn (in polish: Rozbudowa systemu gospodarowania wodami opadowymi na terenie Miasta Olsztyna), [source: https://olsztyn.eu, access: 2.2021].

[21] *Appendix 2 - List of product and result indicators for the program "Development of the rainwater management system in the City of Olsztyn"* (in polish: Załącznik nr 2 - Wykaz wskaźników produktu i rezultatu dla programu “Rozbudowa systemu gospodarowania wodami opadowymi na terenie Miasta Olsztyna”).