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Public Perception of Innovative Technical Solutions for the Development of the 'Sponge City' Concept in Poland: A Case Study of the Tri-City Area

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Abstract: Water resources in the European Union are diverse. For example, Croatia has almost 18 times the water resources that Poland has. Although the key factor causing water shortages is population growth, in Poland this crisis is primarily determined by dynamic development manifested in the country's urbanization and industrialization. These changes are particularly troublesome in urban areas. Therefore, sound remedial and adaptive actions related to the development of the "sponge city" concept are necessary. The implementation of this concept contributes to a reduction in rainwater losses and the heat-island effect. The success of this concept implementation is largely determined by the opinions of city residents towards it, which makes the results of this research important. This article presents opinions of respondents about innovative technical solutions surrounding the "sponge city". This research was conducted by means of a survey method. The statements were formulated based on a critical analysis of the literature. The research was carried out in one of the Polish agglomerations, using the CAWI technique. The results achieved are discussed after their detailed statistical analysis. The respondents' opinions on the impact of implementing innovative technical solutions for the development of the "sponge city" concept were not strongly differentiated. The level of their knowledge was relatively low. Therefore, it is important to undertake activities aimed at both education on this problem and marketing activities in promoting its importance for both the environment and quality of life.

Keywords: water management; Poland; "sponge city"; technical innovations; feature significance index (FSI)

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1. Introduction

Rainwater management in urban areas determines the way cities function and affects their sustainable development, ensuring a high quality of life for their residents, and is particularly important in the context of both climate change and ongoing urbanization. Effective rainwater management can only be achieved by implementing all three of technical, economic, and social solutions. The results of scientific research undertaken due to the need to manage rainwater in accordance with the concept of sustainable development are of great importance for preventing floods and droughts and contribute to the protection of water resources for future generations. The management of water resources poses a challenge not only to water supply companies, but also to economists and decision-makers,

especially local ones, whose actions are often determined by the opinions of local communities. Effective planning and management of water resources, including activities aimed at replenishing resources from rainfall, are crucial for the rational use of groundwater [1]. The concept of integrated management of water resources also underpins many international, national, and regional water management programs, which emphasizes its importance as a guideline for effective rainwater management [2].

The growing threat of drought due to climate change has underscored the critical need to develop effective water management strategies to ensure water security and resilience in various regions of the world, including Poland. In response to this pressing issue, it is necessary to consider implementing adaptation measures that focus on retaining rainwater. This process elicits additional benefits related to preventing the formation of urban heat islands, which in turn improves the quality of life of residents [3].

Poland, like many other countries, faces multiple challenges in water management, especially in the context of the increasing threat of drought. Despite the seemingly abundant water resources in the country, certain concerns have arisen about the efficiency and sustainability of current water management practices. A noteworthy observation is the negative trend in prioritizing rapid discharge of rainwater to the Baltic Sea, which may not be in line with sustainable water management principles. Water retention plays a key role in increasing water availability [4].

Water is one of the most valuable natural resources globally. Therefore, water retention from precipitation and its reuse should be a primary goal considered during the modernization of cities. Rapid urbanization and climate change observed in recent years have led to problems surrounding the management of rainwater in cities. Finding a viable solution to these problems would not only counteract threats to the functioning of cities and the lives of their residents, but would also affect urban development. Traditional methods for preventing flooding are mainly based on discharging water through pipelines, and thus do not provide the possibility of rainwater recycling [5,6].

In both large and small cities, urban surfaces are increasingly being covered with materials such as asphalt, paving/granite blocks, or concrete, which contributes to the intensification of heat waves, reduces water retention, and promotes flash floods. The topography of the terrain on which these surfaces are located is also essential. When water hits these surfaces, it has no chance of penetrating into the ground, and quickly flows down to lower areas or to storm drain systems. As a result, rainwater is often wasted in cities. Therefore, there is a need to take actions to slow down the runoff of water or to completely manage rainwater. Effective methods for rainwater management in cities would ensure proper discharge of water into the ground and prevent the flooding of buildings [7].

The concept of a "sponge-city" refers to urban planning that aims to manage rainwater in a way that maximally mimics natural processes and enables the collection, penetration, and treatment of rainwater in urban areas, while ensuring flood protection and water discharge. This concept promotes the use of rainwater resources as well as the protection and restoration of the ecological environment [5]. "Sponge city" entails an innovative approach to rainwater management in cities, the aim of which is to increase the resilience of urban areas to environmental changes and their ability to effectively cope with natural disasters caused by rainfall. This concept takes into account local conditions to improve water ecology and ensure water security and environmental protection, and to effectively manage water resources. However, its implementation and development requires harnessing various techniques that allow for the development of green infrastructure in civilization-transformed areas, such as rooftop gardens, green spaces, permeable pavements, and rainwater collection systems. They allow rainwater to pervade the ground and reach

urban aquifers, and consequently enable its purification and subsequent extraction, thereby contributing to sustainable water management [8].

Innovative systems covered with vegetation installed on the roofs and walls of buildings (called green roofs and green walls, respectively) have earned much attention in recent years due to their offered multitude of environmental, social, and economic benefits. They contribute to rainwater management through water retention but also promote air purification and mitigate the urban heat island effect by lowering surface temperatures. In addition, they support biodiversity by providing habitats for birds and insects in urban areas and contribute to energy savings by insulating buildings, reducing heating and cooling costs, and extending the life of roof coverings. Last but not least, these systems also improve the aesthetics of buildings, increase property values, and provide opportunities for community involvement in environmental protection [9].

In turn, rain gardens represent a sustainable rainwater management practice that merges landscaping and water conservation to mitigate the effects of urban runoff. Rain gardens are depressions overgrown with vegetation designed to collect, absorb, and filter rainwater from impervious surfaces such as roofs, driveways, and sidewalks. They allow rainwater to pervade the soil, thereby helping to reduce the volume and velocity of the runoff, prevent erosion, and improve water quality. In addition, they improve the aesthetics of landscapes, provide a habitat for wildlife, and minimize the need for irrigation compared to conventional lawns [9].

Water reservoirs play a key role in the "sponge city" structure, serving as storage and infiltration points for rainwater. These reservoirs, whether natural or artificial, contribute to improving the overall water balance of urban areas and support the goals of this concept [10].

Another solution is flower meadows. The benefits of combining conventional lawns with meadows are multiple and significant. Meadows, composed of tall grasses and diverse vegetation, represent a low-maintenance alternative that contributes significantly to environmental protection. Flower meadows develop without intensive maintenance. They play an important role in air purification by filtering dust particles, cooling and humidifying the air, and producing oxygen more efficiently than closely trimmed lawns. In addition, meadows are highly effective in retaining water, which makes them more resistant during periods of drought. The diverse plant species in meadows create habitats for a variety of animals and insects, supporting biodiversity in urban environments. They also have a positive effect on the local microclimate by retaining water [11]. Unfortunately, their impact on the aesthetics of the surroundings is sometimes controversial. Although the transition from lawns to meadows is indeed conducive to saving time, energy, and money, it cannot be unequivocally stated that it meets all the needs of cities, which by their nature differ from suburban and rural areas. Therefore, it may be speculated that only the combination of lawns with flower meadows will provide a rational solution for cities that will allow respecting the aesthetic expectations of their residents, as the social aspects of the implemented solutions should not be forgotten.

Yet another solution is permeable surfaces, which reduce the loads of conventional drainage systems and improve water quality through natural filtration. Green infrastructure and permeable surfaces have been identified as key elements of adaptation to climate change and urban resilience planning. The use of green infrastructure and permeable surfaces improves urban rainwater management, reduces flood risk, and improves overall environmental quality [12,13].

More advanced methods of reusing rainwater in cities are also being explored. An example would be using rainwater to flush toilets. However, such solutions are still at the modeling stage [14]. Therefore, in summary, it should be stated that most of these

solutions are applicable in the Tri-City. The exception is the flower meadow, which reduces the aesthetic values of both modern and historic cities, such as Gdynia or Gdańsk.

The scientific problem addressed in this work concerns opinions about actions aimed primarily at effective management of freshwater failing to meet the highest safety and quality criteria, such as rainwater. Considering the ongoing urbanization of large areas of Poland and the associated changes in the local environment, as well as rapid global climate change and its consequences, it seems justified to take actions aimed at retaining rainwater in zones accessible to man.

This study, concerning the identification of the opinions of respondents from the Tri-City about the impact of implementing innovative technical solutions on the development of the "sponge city" concept, includes key elements related to improving the concept of sustainable development and the identification of respondents' perspectives surrounding the current problem related to access to a basic good indispensable for everyday life, namely, water.

The research was conducted in the Tri-City (Poland) from 1 May to 25 May 2024. The survey included 500 respondents, with approximately equal representation of both genders and a diverse age range from 18 to 80 years. This is a case study example and these data can support the relevance of the presented material.

2. Materials and Methods

2.1. Study Aim and the Adopted Research Hypotheses

The aim of this study was to identify the opinions of Tri-City residents about the influence of innovative technical solutions on the development of the "sponge city" concept, and to analyze the differences between, and the determinants of, these opinions.

The obtained survey results enabled verification of the following research hypotheses:

(1) the extent of diffusion of expert opinions on the role of implementing innovative technical solutions for the development of the "sponge city" concept among respondents is small,
(2) more women than men identify themselves with opinions about the importance of implementing innovative technical solutions for the development of the "sponge city" concept,
(3) the youngest respondents identify themselves with opinions about the importance of implementing innovative technical solutions for the development of the "sponge city" concept significantly more often than those from the other age groups studied.

2.2. Area of Study

This issue is of the utmost importance due to the dramatically fast pace of climate change, the effects of which include, on the one hand, hardly predictable weather anomalies in the form of torrential rains and, on the other hand, desertification of some areas of the world. Poland serves as an excellent example in this case, as it has been struggling with the effects of the September 2024 flood for several months and, at the same time, is ranked fourth in Europe in terms of the countries with the lowest water resources per capita. Its estimated water resources amount to 1600 m^3/capita/year, while the water stress limit has been set at 1700 m^3/capita/year. This state significantly affects quality of life and development opportunities, which is why it should be considered extremely important in the context of achieving the 2030 Agenda Sustainable Development Goal 6. In addition to taking actions aimed at reducing the causes leading to dynamic climate change, it is also important to pursue solutions that serve to mitigate the outcomes of climate change that have already occurred. Figure 1 shows the location of Tri-City in Poland.

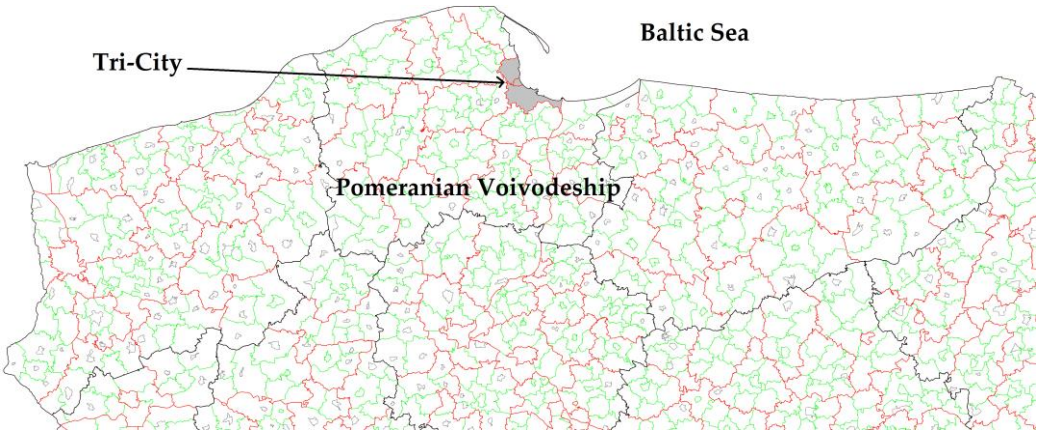

Figure 1. Northern part of Poland—Pomeranian Voivodeship. Source: [15].

The research was conducted in the Tri-City (Gdynia-Sopot-Gdańsk, Poland) from 1 May to 25 May 2024. This region of Poland was selected for this research because it is characterized by a large percentage of residents from various regions of the country. Therefore, it was assumed that the results collected in this region of Poland may reflect the opinions of all Polish residents, although the results of this work should not be treated as representative results for Poland.

2.3. Research Object

Knowledge of opinions plays a significant role in various aspects of management. It provides valuable insights and a comprehensive understanding of diverse perspectives. It is also important in the context of social arrangements. Respondents' opinions allow researchers to determine the significance of the issue being studied by verifying whether respondents understand its essence. In addition, they enable assessing the validity of decisions made, which may affect their social acceptance. Therefore, conclusions from respondents' opinions have practical applications in many aspects of management and social sciences. They help in making good decisions by recognizing social expectations and eliminating incorrect marketing strategies, therefore contributing to effective management.

Surveys are conducted to collect data and information from respondents in a systematic and organized manner. Thus, the results of opinion surveys support making the right decisions, especially at higher levels of management, e.g., at the level of city management [16]. As the experience related to the COVID-19 pandemic has shown, the Polish population, at least in large part, is very willing to accept and implement rational recommendations in conditions of threat, especially when it is well educated in this respect [17]. Therefore, by analogy, it may be expected that the results of surveys can provide data useful for determining appropriate educational actions to be taken in the population. These actions would include the support of authorities in implementing novel solutions, such as the "sponge city", aimed at improving the quality of life of the population.

It should be emphasized that anonymity in research plays a key role in encouraging respondents to provide honest answers and can also increase the number of participants. It enables researchers to obtain more reliable and precise data compared to other research methods, although the usefulness of anonymous data may be more limited compared to confidential data. Thanks to anonymity, research can be more effective and its results more reliable, which ultimately contributes to gathering more valuable information [18].

The object of the research was the opinions of Tri-City residents about the impact of innovative technical solutions on the development of the "sponge city" concept. It should be noted that the term "opinions of Tri-City residents" should be understood as the respondents' relation to the opinions expressed by experts in the field. Only experts

with the appropriate knowledge and skills, and the attitudes developed based on them, surrounding the researched problem and its effects on quality of life and the development of societies possess the acumen necessary to formulate opinions. Therefore, only experts are deemed to be opinion-forming sources.

Collecting a sufficiently large group of respondents allowed the division of participants into three age categories, taking into account, on the one hand, the specificity of the population and its willingness to participate in research, and on the other hand, the requirements related to the need to use statistical tools when interpreting the results (Table 1).

Table 1. Characteristics of respondents.

	Total	**Gender**		**Age**		
		W *	**M ***	**18–35 ***	**36–55 ***	**56–80 ***
n	500	254	246	286	146	68
%	100	50.80	49.20	57.20	29.20	13.60

* W—women; M—men; 18–35—group of the youngest respondents; 36–55—group of middle-aged respondents; 56–80—group of the oldest respondents.

2.4. Research Tool

The research tool was an original survey questionnaire. It consisted of two main sections, the first of which included basic sociodemographic data regarding age and gender, which were arbitrarily considered to be the main factors differentiating the surveyed group of respondents. In the second section, respondents were asked to express their opinion on 10 statements selected arbitrarily based on a critical analysis of the literature regarding the role of implementing innovative technical solutions in developing the "sponge city" concept. All statements included in the survey questionnaire were formulated in the form of simple and unambiguous sentences and concerned the following aspects:

1. improving the efficiency of water retention in the ground [19],
2. sustainable functioning of cities in terms of the natural water cycle [19],
3. improving the sustainability of freshwater abstraction [20],
4. reducing the amount of sewage and relieving the burden on the sewage treatment system [19],
5. reducing the adverse effects of heavy rainfall [21],
6. improving conditions for the functioning of urban ecosystems and green areas [22],
7. increasing the awareness of city residents about the importance of small water retention [23],
8. increasing investment in research on innovative technical solutions [24],
9. increasing competition among companies dealing with innovative technical solutions [25], and
10. reducing the price of these solutions [20].

Respondents expressed their opinions about the 10 selected statements using a 5-point Likert scale, where the individual numbers signified the following: 1—negligible influence, 2—slight influence, 3—moderate influence, 4—strong influence, and 5—huge influence.

The time planned for completing the survey was short, i.e., approximately 5 min, which allowed for reliable answers to be obtained.

Data were collected using the CAWI (Computer-Assisted Web Interview) method. The survey questionnaire was created on the Google Forms platform, and then a link to it was shared on the Facebook platform to achieve a snowball effect. The survey was continued until 500 correctly and completely filled in questionnaires had been submitted.

2.5. Statistical Methods for Data Analysis

The input data gathered using the survey questionnaire were used to identify the significance of differences in the distribution of responses determined by the adopted variability criteria (gender and age category) of the surveyed group of respondents. To this end, the χ^2 test was deployed as a statistical tool, with an adopted significance level of $p \leq 0.05$ [26].

The input data were also used to estimate the value of the feature-statement significance index (FSI) as a source of information about the extent of diffusion of individual opinions in the entire group of respondents. An FSI value exceeding 1.0 indicates a predominance of positive opinions (about a strong and huge influence of the technical solutions) over negative opinions (about a negligible and small influence of the solutions) in the case of a given statement. In turn, an FSI value below 1.0 indicates a predominance of negative opinions about the considered feature over positive ones [27]. As the FSI value increases, the significance of a given feature-statement concerning the impact of innovative technical solutions on the development of the "sponge city" concept increases as well. This was adopted based on Lamm et al. [28], who implemented the solution proposed by Gaworski et al. [27].

In addition, the input data were used to estimate the value of the feature-statement significance index (FSI) as a source of information on the extent of diffusion of respective opinions in groups of respondents homogeneous in specific respects (i.e., gender and age). This approach provided information on the diversity of opinion diffusion with respect to each of the considered statements (opinions) as determined by sociodemographic factors. The estimation and comparison of the value of the feature-statement significance index (FSI) enabled determination of the extent of diffusion of respective opinions among the respondents and its differentiation between respective groups of respondents. In this study, consumer opinions regarding the potential impact of implementing innovative technical solutions on the development of the "sponge city" were assumed to be characterized by a varied level of diffusion not only in the entire group of respondents, but also in subgroups that were homogeneous in a specific respect (gender, age). This made it possible to indicate deficit information, the dissemination of which may appear essential to the development of a campaign promoting the "sponge city" concept in the population. In addition, this information made it possible to identify those groups of respondents among whom the knowledge about the influence of implementing modern and innovative technical solutions for the "sponge city" concept development is lacking and may require educational activities.

The estimation of the feature significance index (FSI) value was based on determining the percentage of opinions indicating agreement with negligible and slight influence (1 and 2, respectively) and the percentage of opinions indicating agreement with strong and huge influence (4 and 5, respectively) in relation to each of the statements concerning the influence of implementing innovative technical solutions on the development of the "sponge city". The feature significance index (FSI) was estimated using the following equation:

$$\mathrm{FSI} = \frac{\mathrm{ps}_{4,5}}{\mathrm{ps}_{1,2}} \quad (1)$$

where $\mathrm{ps}_{1,2}$ is the percentage of opinions denoting agreement with a negligible (1) or slight (2) influence [%] and $\mathrm{ps}_{4,5}$ is the percentage of opinions denoting agreement with a strong (4) or huge (5) influence [%] of the implemented technical solutions [27,28].

The feature-statement significance index (FSI) is a source of information about the extent of diffusion of opinions formulated by experts in the form of statements among respondents. As a result of this research, it was possible to develop a ranking of those statements that describe the potential impact of implementing innovative technical solutions

on the development of the "sponge city" concept. In this way, the survey of respondents' opinions was carried out using a standardized tool, i.e., expert opinions. This approach enabled the avoidance of problems related to the low level of involvement of the respondents in the studied issues, and unreliable completion of the survey questionnaire due to excessive complexity.

3. Results and Discussion

3.1. Differences in Distribution of Opinions Due to Differences in Respondents' Sociodemographic Characteristics

The problem of access to fresh water in Poland undoubtedly has an environmental dimension, determined by climate change [29], which has been triggered by civilizational development [6] and related greenhouse gas emissions [30]. Nevertheless, the social dimension of this problem should not be overlooked, which is related to population's perspectives surrounding the management of very limited fresh water resources, particularly in the face of dynamic climate change. The population's viewpoint surrounding the management of fresh water, usually manifested in their behavior, has been assumed to be conditioned by their knowledge, emotions, and behavioral tendencies, affected by various external factors, including, e.g., the economic availability of water or opinions on the importance of technical solutions for economical water management in practice.

Questionnaire surveys serve as a viable tool for collecting data about respondents' opinions on this important social topic. Therefore, this study aimed to identify respondents' opinions on the influence of implementing innovative technical solutions on the development of the "sponge city" concept, which is defined as a rainwater system with a low environmental impact. The "sponge city" can absorb, infiltrate, but also retain and purify significant volumes of water from heavy rainfall. However, it is also noteworthy that the "sponge city" can release this water during prolonged drought periods [31].

The first stage of this research on the opinions of the Tri-City residents about the influence of innovative technical solutions on the development of the "sponge city" concept involved the analysis of differences in these opinions and their determinants related to gender and age, conducted by means of the $\chi 2$ test, which analyzed the primary data (Table 2).

Table 2. χ^2 test results.

Statement Number	1	2	3	4	5	6	7	8	9	10
Gender $\chi^2_{crit.} = 9.49$	$\chi^2_{calc.}$									
	2.89	16.00 *	6.22	3.26	13.35 *	13.33 *	10.64 *	11.10 *	9.42	7.31
Age $\chi^2_{crit.} = 15.51$	9.97	6.42	3.37	12.55	14.61	3.90	3.97	4.79	8.12	8.67

*—statistically significant differences.

The results obtained showed that age was not a factor statistically significantly differentiating the distribution of opinions towards any of the individual statements, which were assessed by the respondents based on a 5-point Likert scale. Gender, on the other hand, turned out to be a factor that statistically significantly differentiated the distribution of opinions towards statements 2, 5, 6, 7, and 8, as indicated in Figures 2–6, respectively.

Women and men differed in their opinions towards the statement about the influence of innovative technical solutions on the sustainable functioning of cities in terms of the natural water cycle. Generally speaking, women believe that these solutions would have a huge or at least strong impact on the sustainable functioning of cities in terms of the natural water cycle. Conversely, men believed that their impact would be slight or negligible.

Notably, women were more undecided in their views (i.e., there were more women who indicated agreement with technical solutions having a moderate impact) (Figure 2).

These results support the conclusion that although more women than men exhibited a positive relation towards the opinion that the implementation of innovative technical solutions would affect the sustainability of the functioning of cities in terms of the natural water cycle [19], a significant percentage of them expressed indecision on this issue. This statement indicates a clear uncertainty in women towards the opinion that existing technical solutions will directly translate into beneficial changes in cities. This approach can be described as realistic because there is a space—often in the social dimension—between the potential availability of the tool and its implementation. Thus, it was hypothesized that despite being open to technical novelties, women expressed a relatively high uncertainty related to their practical importance, while the opinions of men indicate their clearly conservative relation towards solutions of this type.

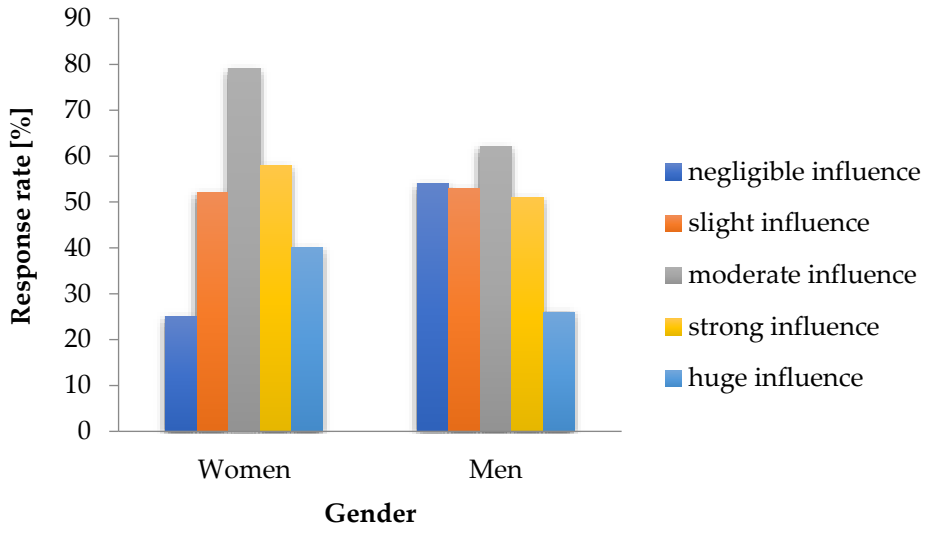

Figure 2. Comparison of the distribution of results concerning the opinions of women and men on the influence of innovative technical solutions on the sustainable functioning of cities in terms of the natural water cycle (statement 2). Source: Own study based on research results.

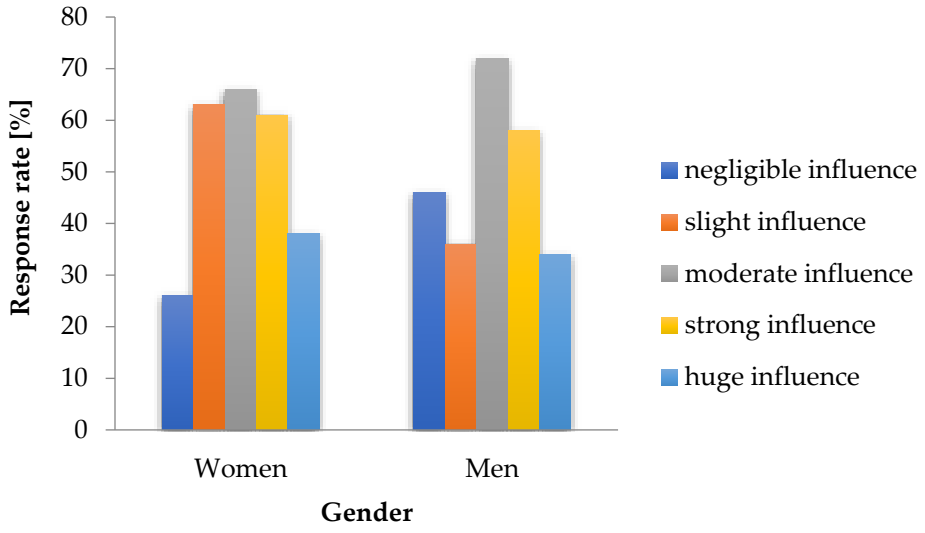

Figure 3. Comparison of the distribution of results concerning the opinions of women and men on the influence of innovative technical solutions on mitigating the adverse effects of heavy rainfall (statement 5). Source: Own study based on research results.

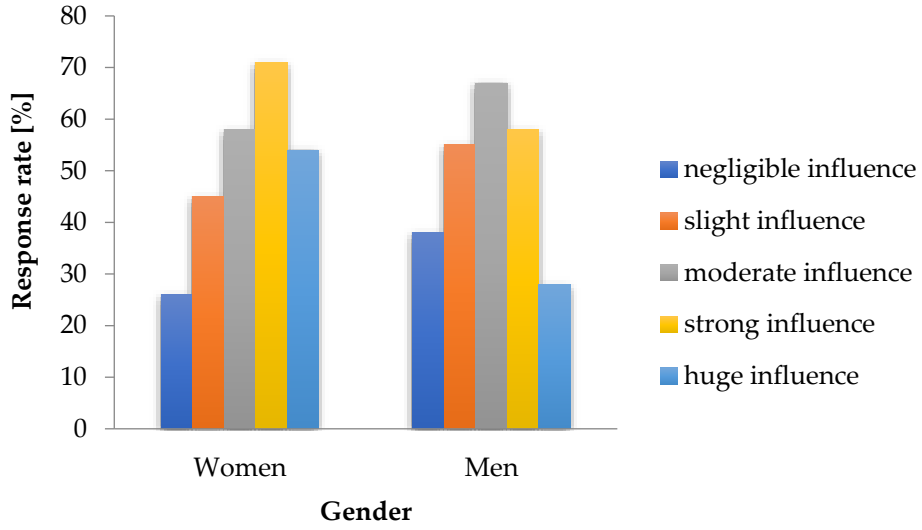

Figure 4. Comparison of the distribution of results concerning the opinions of women and men on the influence of innovative technical solutions on the improvement in conditions for the functioning of urban ecosystems and green areas (statement 6). Source: Own study based on research results.

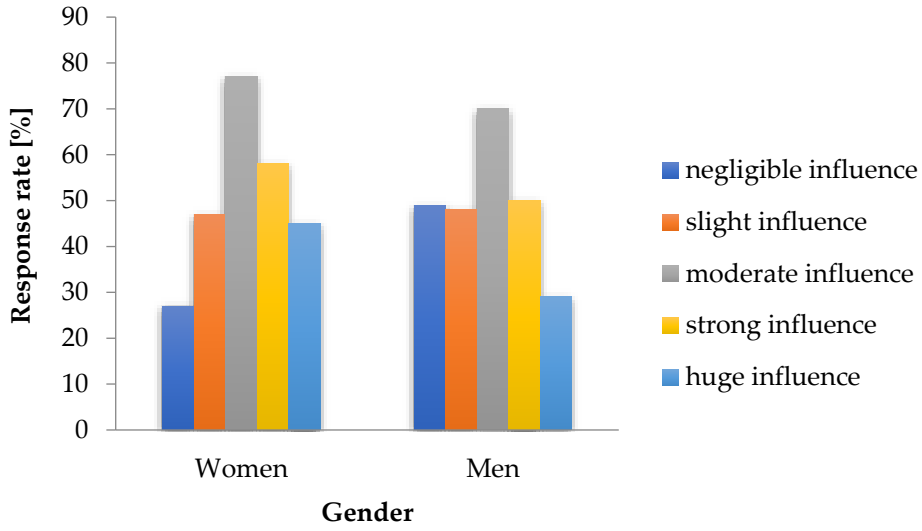

Figure 5. Comparison of the distribution of results concerning the opinions of women and men on the influence of innovative technical solutions on increasing the awareness of city residents about the importance of small water retention (statement 7). Source: Own study based on research results.

It was also established that another area differentiating women and men was their relation with the opinion about the impact of innovative technical solutions on mitigating the adverse effects of heavy rainfall. Although a significant percentage of women believed that these solutions would have a huge or at least strong impact, the percentage of women with the opposite opinion was also significant. The undecided respondents were predominantly men (Figure 3).

These results point not only to the greater confidence of women in the benefits expected from implementing innovative technical solutions to mitigate the adverse effects of heavy rainfall [21], but also to a significantly lower level of uncertainty regarding this opinion. In addition, they can be interpreted as an expression of women's openness to technical solutions as a risk-reducing factor. This approach indicates the innovativeness of this group of respondents, which, depending on their position in the local authorities of the cities constituting the Tri-City, may play a role in decisions surrounding the development of the

"sponge city" concept in the Tri-City in the near future. So far, only one city in Poland, i.e., Bydgoszcz, has taken active steps to implement this concept in practice [31].

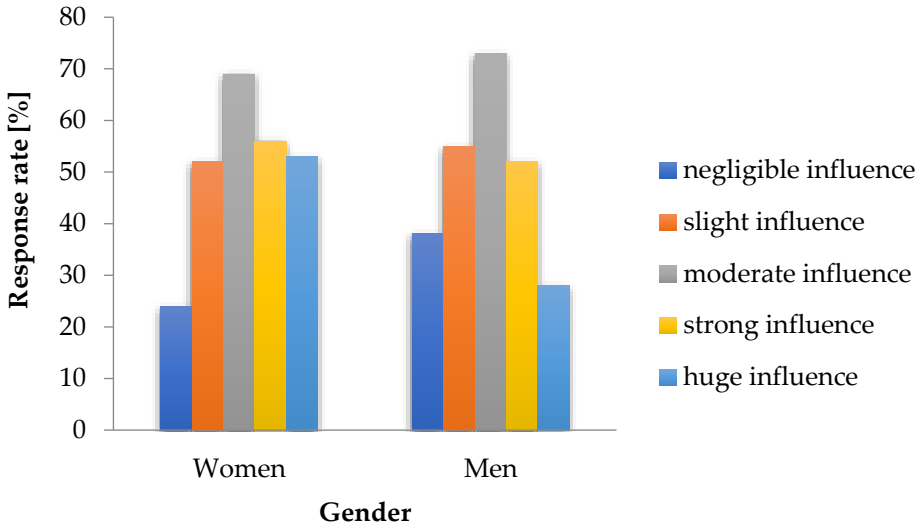

Figure 6. Comparison of the distribution of results concerning the opinions of women and men on the influence of innovative technical solutions on the increase in investment in research on innovative technical solutions (statement 8). Source: Own study based on research results.

The survey results showed that women, much more than men, believed that innovative technical solutions would have a huge or at least strong influence on improving conditions for the functioning of urban ecosystems and green areas. At the same time, significantly fewer women had the opposite opinion. The women were also more decided in their opinions on this matter than men (Figure 4).

The differences found indicate that women foster high hopes surrounding the potential of innovative technical solutions to improve conditions for the functioning of urban ecosystems and green areas, and thus the quality of life in the city [22]. This finding indicates their openness to technological achievements as a factor stimulating the functioning of ecosystems in conditions strongly modified by humans. Because today's cities are called heat islands, it is necessary to take actions to improve the quality of life of their residents. This statement is consistent with several postulates (3, 9, 11, and 13) of the Agenda for Sustainable Development [32].

It was also found that women are much more convinced that innovative technical solutions would have a huge or at least strong influence on increasing the awareness of city residents about the importance of small water retention. However, women also had significant doubts regarding this statement. The men's opinions on this matter were completely different (Figure 5).

The diversification of the distribution of results indicates that although women as a group show a more positive attitude than men towards the impact of innovative technical solutions, this time on increasing the awareness of city residents about the importance of small water retention [23], their attitudes were less enthusiastic regarding this concept compared to the statements discussed earlier. It can be assumed, then, that women are enthusiastic about action on the one hand, but realists on the other hand. Women showed a more positive attitude to the issues related to technological progress as a factor stimulating beneficial changes, while at the same time they were moderately convinced by statements referring to humans as a factor stimulating beneficial changes. This confirms the preliminary assumption of this research: that the problem of access to fresh water in Poland should be perceived not only in the environmental but also in the social context [3]. The social dimension of this problem/challenge is primarily related to emotions, as well as knowledge

and availability of both technical and economic solutions to mitigate the adverse outcomes of climate change.

Women, to a greater extent than men, identified with the opinion that innovative technical solutions will have a huge or at least strong impact on the increase in spending on research on innovative technical solutions. At the same time, fewer women had the opposite opinion or were undecided on this issue compared to men (Figure 6).

It may be concluded from the survey results that women are convinced that the implementation of innovative technical solutions will increase investment in future research on them, and thus contribute to progress in this area [24]. This statement again indicates women's openness to technological progress as a factor stimulating beneficial changes. This approach can be described as an "escaping forward" strategy, characteristic of developed societies with a positive attitude to changes, which are perceived as opportunities and challenges, and not as threats and problems.

In the case of the remaining statements, i.e., 1, 3, 4, 9, and 10, there were no statistically significant differences in the distribution of responses provided by women and men. The analysis of all results enabled concluding that the opinions of the Tri-City residents about the impact of implementing innovative technical solutions on the development of the "sponge city" concept are not very diverse, which may indicate relative homogeneity in the respondents' opinions. It should be emphasized that Poles have been described as a fairly homogeneous nation in many studies addressing important social problems [33,34]. At the same time, the survey results clearly indicate that women are more open to opinions on the multi-faceted, beneficial effects of implementing innovative technical solutions for the development of the "sponge city" concept. Hence, they can be described as innovators in the studied area, and perhaps also a driving force for progress in environmental protection, sustainable development, and improving quality of life, particularly at the local level. These aspects have been highlighted in studies conducted in European countries [35] as well as in developing Africa [36].

3.2. Differences in the Values of the Feature-Opinion Significance Index (FSI) Determined by Differences in the Respondents' Sociodemographic Characteristics

The next stage of the research was devoted to estimating the extent of diffusion of expert opinions on the role of implementing innovative technical solutions in the development of the "sponge city" concept perceived by the entire group of respondents and by homogeneous subgroups in terms of gender and age. Respective results are presented in Table 3.

Gathering the opinions of this surveyed group of the population allowed the achievement of multiple goals, not only cognitive and scientific ones, but above all those from the educational and marketing fields. These goals should serve as a viable tool in effective management of, e.g., rainwater at the local level, in pursuit of the implementation of sustainable development concepts, particularly at the "sponge city" level. It should be emphasized that improving the water situation by implementing this concept in Poland may, over a certain time span, translate into a permanent improvement in the quality of life in cities. It is equally important to note this concept can be implemented using funds from the National Reconstruction Plan. It is noteworthy that, pursuant to the European Union objectives, a significant part of this budget is allocated for climate purposes (44.96%). As part of the green transformation of cities, significant funding can be obtained for green investments, including, e.g., development of the "sponge city" concept [37].

It is therefore important to recognize the level of expert opinion diffusion among respondents based on the FSI value. It should be assumed that while there will be no problems with financing the activities aimed at implementing this concept, tolerance to, and thus acceptance of, temporary difficulties related to city area functioning affected by

changes triggered by this implementation will probably be a function of opinion diffusion. It should also be expected that interest in developing this concept in terms of implementing innovative technical solutions on private land (single-family housing) will also be strongly correlated with the extent of opinion diffusion. Therefore, it is important to identify the extent of diffusion of key opinions and indicate those that are characterized by low FSI values (below 1.0) [27,28], and consequently implement appropriate educational and marketing actions.

Table 3. Values of the feature significance index (FSI) regarding the influence of innovative technical solutions on the development of the "sponge city" concept.

The Issue Considered in the Statement: Innovative Technical Solutions for the Development of the "Sponge City" Concept Affect . . .	**Value of the Feature-Statement Significance Index (FSI)**					
	Total	**Gender**		**Age**		
		W *	**M ***	**18–35 ***	**36–55 ***	**56–80 ***
Improvement in the efficiency of water retention in the ground	1.06	1.15	0.95	1.04	1.02	1.24
Sustainable functioning of cities in terms of the natural water cycle	0.95	1.27	0.72	1.02	0.95	0.71
Improvement in the sustainability of freshwater collection	1.28	1.65	1.00	1.35	1.26	1.09
Reduction in sewage volume and in sewage treatment system loading	1.18	1.32	1.06	1.22	1.04	1.35
Mitigation of the adverse effects of heavy rainfall	1.12	1.11	1.12	1.14	0.94	1.43
Improvement in the conditions for the functioning of urban ecosystems and green areas	1.29	1.76	0.92	1.31	1.11	1.67
An increase in the awareness of city residents about the importance of small water retention	1.06	1.39	0.81	1.21	0.87	1.39
An increase in the investment in research on innovative technical solutions	1.12	1.43	0.86	1.12	1.08	1.28
An increase in competition among companies dealing with innovative technical solutions	0.93	1.23	0.70	1.11	0.75	0.70
A decrease in the price of these solutions	0.88	0.98	0.80	0.92	0.88	0.73

* W—women; M—men; 18–35—group of the youngest respondents; 36–55—group of middle-aged respondents; 56–80—group of the oldest respondents.

In addition, it is important to recognize the extent of differences in opinions' distributions determined by differences in the respondents' sociodemographic characteristics and to identify groups of respondents characterized by a small extent of opinion diffusion who, consequently, show a conservative attitude towards the impact of innovative technical solutions on the development of the "sponge city" concept.

The first step of this research on the extent of opinion diffusion among the respondents, conducted using the feature significance index (FSI), involved estimating its value based on data describing the entire group of respondents (Table 1). Based on the approach posited by Gaworski et al. [27] and then adapted by Lamm et al. [28], it can be stated that the FSI value expresses the ratio of opinions with a positive tone to opinions with a negative tone. An FSI value above 1.0 indicates a predominance of positive opinions over negative opinions regarding a given feature-statement, and a high value indicates a large extent of diffusion [27,28]. In turn, an FSI value below 1.0 indicates a predominance of negative opinions over positive ones.

Very high FSI values should not have been expected given the fact that the survey was conducted among random respondents who were not experts in this field and were not prepared in any way to participate in this study, e.g., by attending a lecture on the "sponge city" concept [27]. The highest FSI value (1.29), determined based on the results achieved for the entire group of respondents, concerned the statement about the improvement of conditions for the functioning of urban ecosystems and green areas under the influence of innovative technical solutions for the development of the "sponge city" concept. It was also shown that negative sentiment prevailed over positive sentiment in the case of only 3 out of the 10 analyzed statements, which indicates a relatively large extent of diffusion of these opinions among the respondents (Table 2). The opinions with a low FSI value were predominated by those referring to the economic aspects related to technical innovations, which is not a problem in practice due to the available measures for implementing these solutions. Therefore, the hypothesis that the extent of diffusion of expert opinions on the role of implementing innovative technical solutions for the development of the "sponge city" concept among the respondents is small was positively verified.

The next goal of the study was to determine and compare the FSI values estimated based on the results obtained for the groups of women and men separately (Table 2). The analysis of these results enabled formulating an explicit conclusion that the extent of diffusion of the surveyed opinions among women was much larger compared to men. This was indicated by significantly higher FSI values. Moreover, in the group of women, negative sentiment prevailed over positive sentiment only in the case of the statement regarding the impact of implementing innovative technical solutions for the development of the "sponge city" concept on reducing the price of these solutions. On the other hand, among the men surveyed, negative sentiment prevailed over positive sentiment in relation to the majority of statements, i.e., as many as 7 of the 10 examined. The results of this survey can be analyzed in the context of findings from a cross-sectional survey conducted by Prokop et al. [38]. Thus, the hypothesis assuming that women, to a greater extent than men, identify themselves with opinions about the important role of implementing innovative technical solutions for the development of the "sponge city" concept was verified unequivocally positively.

The last stage of the study aimed to determine and compare the FSI values estimated based on the results obtained for the individual age categories of respondents (Table 1). The extent of diffusion of the surveyed opinions among the youngest respondents was a slightly larger compared to the respondents from the remaining age categories. The youngest respondents identified themselves to a slightly greater extent with the opinions about the important role of implementing innovative technical solutions for the development of the "sponge city" concept. Similar observations were made by Maciejewski [39] as well as Ilbeykina et al. [40] based on the results of studies on the attitudes of young people, especially towards technical innovations. Therefore, the third research hypothesis was also verified positively.

In summary, it can be stated that the research results and the method deployed to verify the adopted research hypotheses provide grounds for formulating optimistic conclusions regarding the perception of the impact of innovative technical solutions on the development of the "sponge city" concept by Tri-City residents. The analysis of opinions indicates a relatively satisfactory level of understanding of the problem ("sponge city" development). In addition, it shows a positive sentiment towards innovative methods for solving this problem, at least in groups whose investment in the importance stimulating progress is increasing. On the other hand, educational and marketing activities promoting this concept should be targeted especially at men, as well as middle-aged and older persons.

4. Conclusions

The obtained results indicate that the respondents' opinions on the analyzed problem were affected by the relatively low level of their knowledge about both the "sponge city" concept and the importance of innovative technical solutions for rainwater management in cities. The first hypothesis was verified positively. Therefore, it seems important to undertake activities aimed at both education on this problem and marketing activities in promoting its importance for both the environment and the quality of life.

The opinions of women indicate their more positive attitude compared to men towards innovative technical solutions as a factor contributing to the development of the "sponge city" concept. The second hypothesis was verified positively.

However, no significant differences were found between the opinions of respondents of different ages. The third hypothesis was verified positively.

In the respondents' opinion, innovative technical solutions specific to the "sponge city" concept will primarily contribute to improving the conditions for the functioning of urban ecosystems and green areas. At the same time, these opinions indicate that their implementation will have little impact on reducing the price of these solutions.

The growing threat of drought in Poland requires proactive actions to increase water retention in the landscape and improve water management practices. By prioritizing sustainable strategies, Poland can better adapt to drought threats, ensure water security, and promote ecosystem resilience to climate change. Collaboration among decision-makers, stakeholders, and communities in implementing these strategies is essential to protect water resources for current and future generations.

Existing financing opportunities, and government incentives such as tax breaks and subsidies, can help offset the costs of installing innovative technical solutions in the "sponge city". They can also promote interest in these solutions in private urban areas (single-family housing). Awareness campaigns and educational programs can also help increase understanding of the benefits from implementing these solutions and encourage the local community to participate in green initiatives.

Considering the fact that spring in Poland is a relatively rainy period, but is normally free from floods, this study should be repeated in late summer. At that time, Poland experiences high temperatures and droughts, which are interrupted by very heavy rainfall. Such events may influence respondents' opinions on taking action to reduce such threats. An important aspect of further research on the "sponge city" concept should also be the recognition of developers' opinions.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. Ethical review and approval were waived for this study, due to this study was designed as a non-interventional study. This study examined the influence of innovative technical solutions on the development of the "sponge city" concept. This study was conducted using an original questionnaire that contained information relevant to potential participants. The statements included in the questionnaire did not interfere with the respondent's physical and/or mental sphere. The results obtained in this study, as well as the conclusions drawn from them, did not

refer to the respondents (humans). Due to the above, the consent of the Research Ethics Committee of Gdynia Maritime University was not required.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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