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WATER CITY INDEX 2024

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EFFICIENCY RANKING OF WATER RESOURCES USE IN POLISH CITIES

WATER CITY INDEX 2024

EFFICIENCY RANKING OF WATER RESOURCES USE IN POLISH CITIES

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INTRODUCTION

PROF. JERZY HAUSNER

The Water City Index is part of a larger project called Open Eyes Economy, which we define as an expert-civic movement. We focus in it on undertaking actions of practical usefulness. This practical dimension cannot be disconnected from a specific cognitive perspective, which in our case is the economy of values. This cognitive perspective allows us to go beyond the established thinking patterns about many key socio-economic problems. It enables us to view rural areas and agriculture as the food-environment-territorial development connection. This immediately redefines the relationship between agricultural activity and water management and includes also the issue of urban food production. In the past, the energy issue implied power generation, today we know that it is a blind alley. You cannot discuss power generation alone, you need to discuss energy itself. And the way the problem is posed is fundamentally different – it's not about producing as much energy as possible, but about using it as wisely and productively as possible. A cognitive perspective that is appropriate to the changing reality is the starting point for formulating an effective strategy and opens the way to its practical application. In the background, there is always the issue of an adequate institutional arrangement that allows such strategy to be developed, as well as agreed on, enforced, and implemented. In Poland, this becomes particularly crucial regarding water management. Change is essential. It concerns the division of competencies, the ability to coordinate actions, the legal coherence, an efficient monitoring and control system, as well as reasonable budgeting of activities. It means also budgeting that allows for the implementation of cross-sectoral rather than siloed projects. Eventually, such change involves effective social communication and educational impact. All of this is lacking in our country. This matter also relates, among other things, to the relationship between the responsibilities and scope of influence of the Ministry of Infrastructure and the Ministry of Climate and Environment.

Generally, it is required to identify water as a key developmental resource. Consequently, it's necessary to implement a genuine, well-considered and effective institutional reform that includes also the local government system. One of the aspects concerns how it should be integrated into spatial planning. In this case, the institutional deficit is particularly noticeable and has serious consequences. For years, recommendations framed by our community have been dismissed by decision-makers. We still trust that this will change. Perhaps another major flood in the Oder River basin would contribute to this. Once again, we are witnessing a great civic mobilization of Poles in response to a massive threat and a flood disaster. Those directly affected are facing an exhausting fight with the forces of nature and defence of their communities. A mass mobilization. Others are coming to their aid. We must believe that energy and support will not be lacking even after the physical danger diminishes, and the difficult reconstruction will become the most important task. There are no technical systems that can fully protect people and their property from the effects of natural disaster. The current, unfortunately yet another, major flood could not have been prevented. However, it does not mean that more could not have been done in the Oder River basin after the 1997 disaster, and that better flood prevention measures could not have been taken in various locations. This includes enhancing the rescue and emergency management system. Nevertheless, in the face of natural forces, the case is always that it is never enough, despite much being done. This is why civic mobilization is essential – nothing can replace it. The ability to authentically unleash this energy is one of our strengths. Unfortunately, it is a type of energy that flares up quickly and fades just as fast. It is effective in times of crisis but does not serve well for systematic and painstaking recovery and developmental efforts. Hence, as a society we are poorly prepared for various shock events, and we are seeing this now as well.

KRZYSZTOF KUTEK

A new edition of Water City INDEX is released as we are faced with yet another water crisis. In recent years, we have successfully responded to the strain on drinking supply systems caused by the influx of refugees from Ukraine, the Oder river crisis resulting in tonnes of dead fish, and an annual drought. Today, we are struggling with the effects of the great flood. The great water made its autumnal, and therefore unusual, comeback, but it reminded us that things are changing and calling for our attention. It is the climate that is changing, which we have long known, but somehow we still needed evidence, and so the nature brutally supplied us with ample evidence. Did we get prepared? Looking at the scope of destruction or looking at the map, one could say that we have done nothing since the previous great flood, we have not learnt our lesson. Or perhaps not entirely. Many facilities have been built with a view to reducing the risk of flooding, such as the Racibórz Dolny reservoir or reservoirs in the Kłodzko Valley. However, as it transpired, it was not enough, people suffered again, and again the water turned out to be too much to take. Today one may read and hear different diagnoses from different experts. The usual question is, 'why'? Why, despite actions, investments and knowledge, did it happen yet again?

We certainly need to think constantly about water. It is clear that in recent years we have had problems with these areas that we keep referring to as: "too much", "too little", "poor quality", or "water shortage". Everyone should take care and pay attention to the valuable natural resource that is water, not only when a lack or excess thereof occurs. Water requires protection, and everything should be done to ensure that water does not run out, that it is clean and that it does not cause harm. We should bear this in mind in times when we are able to act and prepare for crises. What this requires is continuous work, implementation of systemic actions, and institutional cooperation. This is the likely key to success. Efficient warning systems, no blurred responsibility, prepared facilities, accurate decision-making and, most importantly, awareness and knowledge of residents about appropriate actions to be taken in times of danger. Let us hope that this year's water crisis will trigger a sequence of events that will have a positive impact on reducing the risk of further crises, and not only those related to flooding.

The current Water City INDEX also discusses the water footprint of cities. Each of us leaves something behind. The water footprint is among these things. Cities use water in different ways, thus generating the footprint. It is obvious that the water footprint cannot be reduced to zero as because without water there is no life or development. However, we regard water as the most valuable resource on which we have built and will continue to build. Cities are growing and their water consumption is increasing not only because of the number of residents, but also because of the desire for a high quality of life. Today, information about the kind of footprint we leave is of extreme value, just as is the knowledge whether we can reduce that footprint and consume less water. Awareness of how much water we pour should help us understand that saving water and paying attention to its social and economic value are necessary for life. I would like this year's results of our work to cause a stir and awaken in each of us the desire to actively work on reducing the water footprint and respecting this very valuable resource. Everyone has an influence on ensuring that future generations can enjoy natural resources just like we do, let us therefore try not to waste this opportunity and use water in a reasonable and responsible manner.

APPLIED RESEARCH METHODOLOGY

The 2024 Water City Index was developed on the basis of the very same method which was employed in previous rankings. As in previous years, great emphasis was placed on measuring activity of local self-governments and on direct effects of their policies through the use of indicators which show changes in values thereof occurring in the years 2019-2023.

The 2024 Water City Index was prepared traditionally for three categories of Polish cities: metropolises (8 cities), other cities with poviat rights (58), and cities which are not cities with poviat rights, which in the year the first edition of the WCI had at least 20,000 inhabitants (152). Eight metropolises were separated from the group of cities with poviat rights on the basis of criteria such as the number of inhabitants (at least 200,000 inhabitants), the degree of technological advancement of water supply and sewage infrastructure, as well as the complexity of social and economic problems.

The 2024 WCI includes 3 categories and 15 subcategories of assessment. The index of cities which are not cities with poviat rights was developed on the basis of one collective category. Arrangement thereof is shown in the figure below.

The sequence of activities in creating the index was as follows:

- division of urban water policy into 3 areas;
- division of areas into 13 categories;
- quantification of 13 categories with the use of a set of over 40 indicators;
- obtaining quantitative data;
- assigning weights to indicators and indices for individual categories;
- aggregation of results and interpretation of data.

FIGURE 1. AREAS AND CATEGORIES OF URBAN WATER POLICY ASSESSMENT

Source: own study

For the purposes of calculating the index for cities with poviat rights, there were applied over 40 different indicators, obtained from the following sources:

- Local Data Bank of the Central Statistical Office (Bank Danych Lokalnych Głównego Urzędu Statystycznego, BDL GUS);
- Database of Topographic Objects (Baza Danych Obiektów Topograficznych, BDOT10k);
- Flood Hazard Maps (Mapy Zagrożenia Powodziowego, MZP);
- Institute of Meteorology and Water Management – National Research Institute (Instytut Meteorologii i Gospodarki Wodnej – Państwowy Instytut Badawczy, IMGW – PIB);
- Polish Waterworks Chamber of Commerce (Izba Gospodarcza Wodociągi Polskie);
- own survey conducted among cities with county rights.

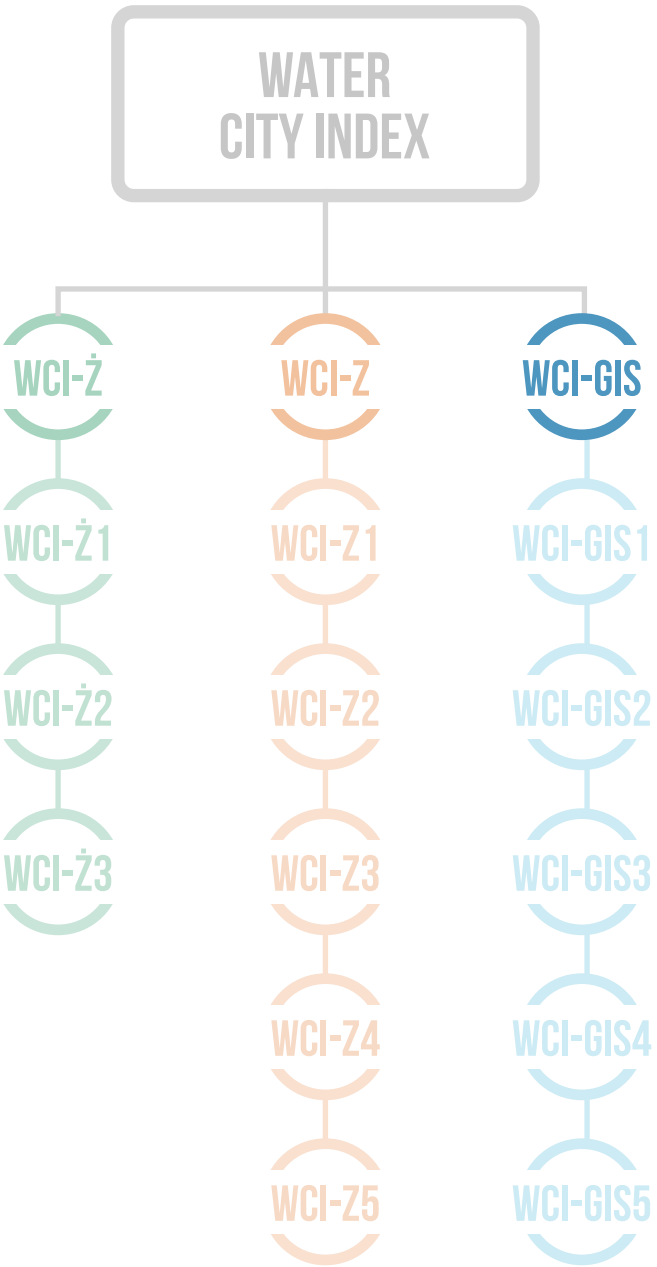
Rating in the **"Life"** category was based, among others, on the following indicators: price and change in water consumption in the city, price and production of sewage, density of the water supply and sewage network in the city, and expenses incurred by cities on wastewater management and water protection. In the **"Danger"** category, the index was calculated on the basis of such indicators as: the share of the city's area in the flood hazard area, the length of flood embankments in relation to the area of the flood hazard area in the city, annual rainfall per sealed area, the number of water supply failures per the total length of the network, or the percentage biologically active areas within the city. Index for the **"Economy and business"** category was calculated, among others, on the basis of water consumption by industry, the number of companies operating in the water transport industry, or the number of watercourses (bridges) crossed in relation to the length of watercourses in the city. The last area (**"Culture and inhabitants"**) was based on such indicators as: the length of the city's coastline, the percentage of surface water in the city's area, the change in the share of parks, green areas and green housing estates in the total area, and the change in the share of cities' expenditure on maintaining greenery in their own income. All indicators were subjected to a standardization process with the use of the following formula:

$$t_{ij} = \frac{X_{ij} - \bar{X}_j}{S_j}$$

Where:
t_{ij} – value of the standardized measure *j* for the city *i*
X_{ij} – value of measure *j* in the city *i*
X_j – arithmetic mean of measure *j*
S_j – standard deviation of measure *j*

Standardization run in individual assessment categories allowed for creating four indices (WCI-Ż, WCI-Z, WCI-G, WCI-K), which constituted the basis for building one main index (WCI). The values achieved by metropolises and other cities with poviat rights were the basis for developing the main and detailed rankings (separately for each category) presented in this report.

FIGURE 2. STRUCTURE OF WATER CITY INDICES



Source: own study

The authors are aware that some of the strengths and weaknesses of cities in the context of the Water City Index may result from natural conditions (determinants which are uncontrollable from the point of view of city authorities), and some from controllable factors: spatial, environmental, economic, and social conditions of cities. Therefore, the Water City Index uses numerous indicators which show the city's progress over the last 4 years (2023 vs 2019). Nevertheless, it is worth looking at the classification from the perspective of the changes which a given city has achieved over recent years, rather than the absolute result and position in the ranking.

EDITING: KLARA RAMM

HOW DO THEY DO IT IN AUSTRALIA

In 1950, one third of the world's population lived in cities; in 2050, this number will amount to two thirds of the world's population. It is therefore important to create appropriate living conditions in urban areas. According to the WHO concept, a city has one health shared by all its inhabitants, both humans and all other organisms. The poor condition of some of them results in deterioration of the functioning of others. Without clean and healthy water resources, there is no healthy city.

As part of the Water City Index, we take a close look at the Polish cities. Our ranking is rooted in the Polish reality, but this does not mean that we are not interested in water indicators functioning in other countries. This year, we have decided to invite the authors of the water ranking methodology for Australian cities. We therefore present the evaluation of the functioning of Perth as an example of using the "Water Sensitive Cities" indicator.

Perth's transition to more sustainable water system services as an example of the use of the Water Sensitive Cities Index

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INTRODUCTION

Monash University, through the Cooperative Research Centre for Water Sensitive Cities (CRCWSC), has been undertaking research and working in Australia and the Asia-Pacific to assist cities with their blue-green transformation.. The Water Sensitive Cities Index (WSC Index) is used to navigate pathways for providing greater value to communities from water system services. Perth in Western Australia, is one of the cities that has used the Water Sensitive Cities Index to benchmark its transition progress over a five year period from 2016 to 2021. Through the CRCWSC, Monash University worked with six Australian cities – Perth, Adelaide, Bendigo, Sydney, Townsville and the Gold Coast – to examine changes in their water servicing over time and explore their water sensitive city aspirations (Hammer et al. 2020). For each case study city, the research involved a desktop review of local policies and plans (e.g. water, environment, planning, health, community, sustainability, liveability, resilience), stakeholder interviews and a series of participatory workshops.

EMERGING VISION FOR AUSTRALIAN WATER SENSITIVE CITIES

Water sensitive city visions were developed through the research's participatory workshops with the six case study cities which ranged in scale, biophysical and social contexts and institutional arrangements. They also differed in people's relationships with water, with historical responses to certain drivers shaping how water is currently viewed and managed. Despite these contextual differences, cities articulated common themes regarding future water sensitive aspirations for their city in 50 years (Figure 2).

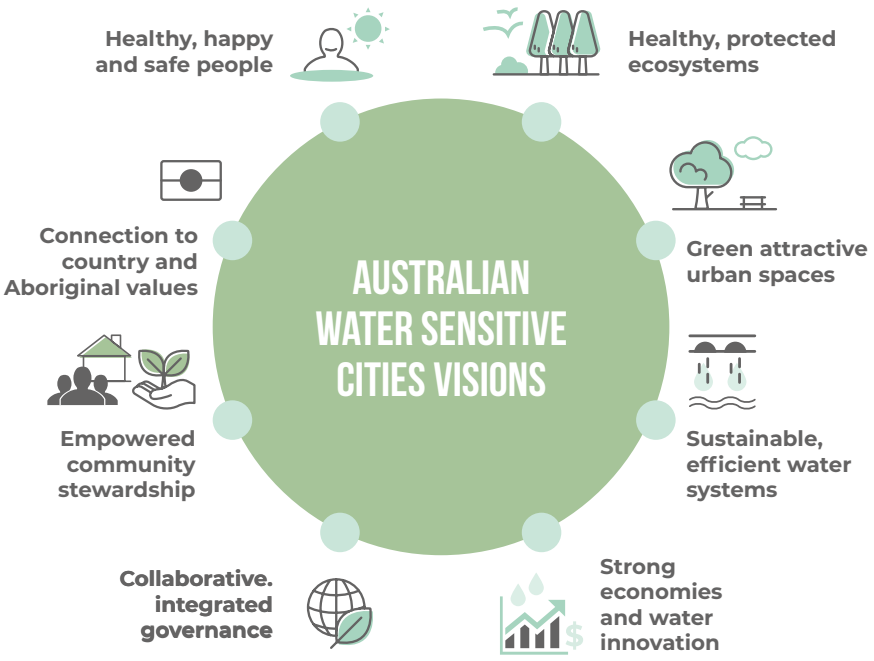


FIGURE 2. VISION FOR AUSTRALIAN WATER SENSITIVE CITIES (HAMMER ET AL. 2020)

THE WATER SENSITIVE CITIES INDEX

Planning a city's transition to its WSC vision requires a detailed understanding of its current performance in relation to its aspirations. The CRCWSC's Water Sensitive Cities Index(Rogers et al. 2020) is a benchmarking tool designed for this purpose. It articulates seven WSC goals, which organise 34 indicators representing the major attributes of a WSC (Figure 3).

These goal areas cover both biophysical and socio-institutional elements, which are organised into 34 corresponding indicators. Each of the 34 indicators is scored on a 1 to 5 rating scale in a collaborative workshop process based on detailed descriptions and (where available) quantitative criteria in the benchmarking tool. A score of 5.0 represents the aspirational water sensitive performance for each indicator. The scores are plotted to visually display where a city's strengths and weaknesses lie across the seven goal areas – establishing a benchmark for the city at that point in time. The tool is applicable to cities of all scales, from a broad metropolis to a local government area. Following benchmarking, the Index tool supports the city to set targets and identify strategic priorities and actions to improve water sensitive performance and ultimately reach the water sensitive cities vision. Progress towards the achievement of the vision can be measured through subsequent applications of the Index benchmarking tool.

FIGURE 3. SEVEN GOAL AREAS THAT CHARACTERISE A WATER SENSITIVE CITY

The transition strategies developed with the six case study cities show how each is planning to address their priorities through action tailored for their local context (Gunn et al. 2017, Rogers et al. 2017, Rogers et al. 2018, Hammer et al. 2018a, Hammer et al. 2018b, Hammer et al. 2018c). Common transition priorities across the cities include (see Hammer et al. 2020 for more details):

- A shift in leadership from top-down to distributed, bottom-up and adaptive models, with leadership at all levels and from a range of perspectives and expertise.
- Stronger collaboration to maximise opportunities, improve efficiency, and deliver broad city outcomes through water management.
- A culture of innovation and experimentation to support new solutions across technical, design and social domains, underpinned by acceptance of a certain level of managed risk and learning from innovations that do not succeed.
- Increased organisational and professional capacity to implement integrated, water sensitive solutions, including understanding of cross-sectoral and cross-disciplinary linkages and research partnerships to support the development of new solutions.
- Open and transparent data and platforms supporting the sharing of knowledge across boundaries, including organisations, councils, cities and countries.

A CASE STUDY OF PERTH, WESTERN AUSTRALIA

Perth has seen climate change happen faster and earlier than almost anywhere else on the planet. Since 1970, Perth's rainfall has decreased by more than 20%, with climate models predicting a further 6% reduction over the state's south west by 2030 (Water Corporation, 2022a). This decrease in rainfall has resulted in an 80% decline

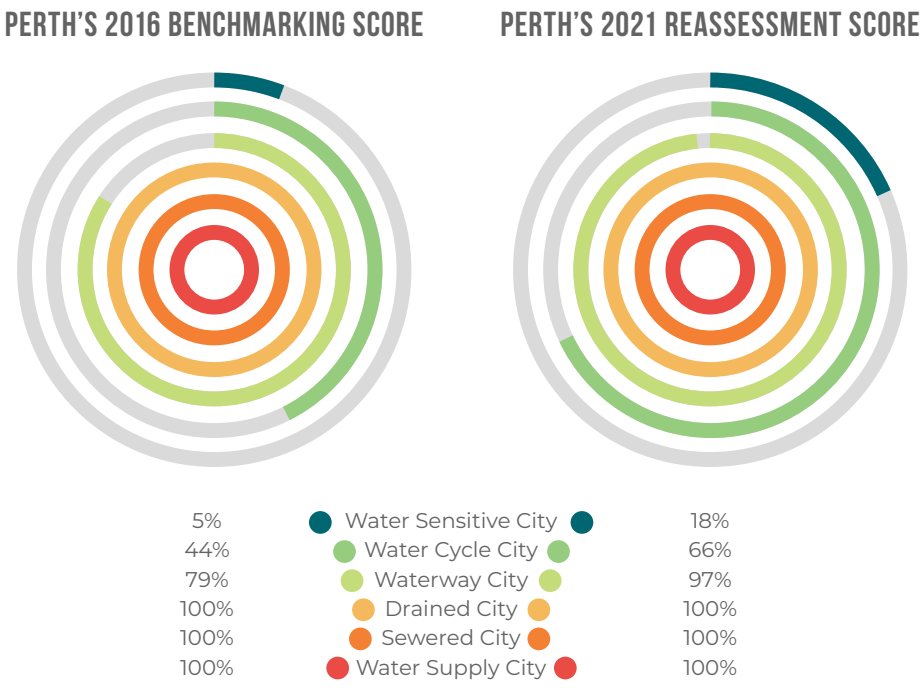


FIGURE 4. PERTH'S 2016 BENCHMARKING SCORE (LEFT) COMPARED TO THE 2021 REASSESSMENT (RIGHT). THE SCORES ARE PRESENTED AS A PERCENTAGE ATTAINMENT OF EACH OF THE CITY-STATES OF THE URBAN WATER TRANSITIONS FRAMEWORK

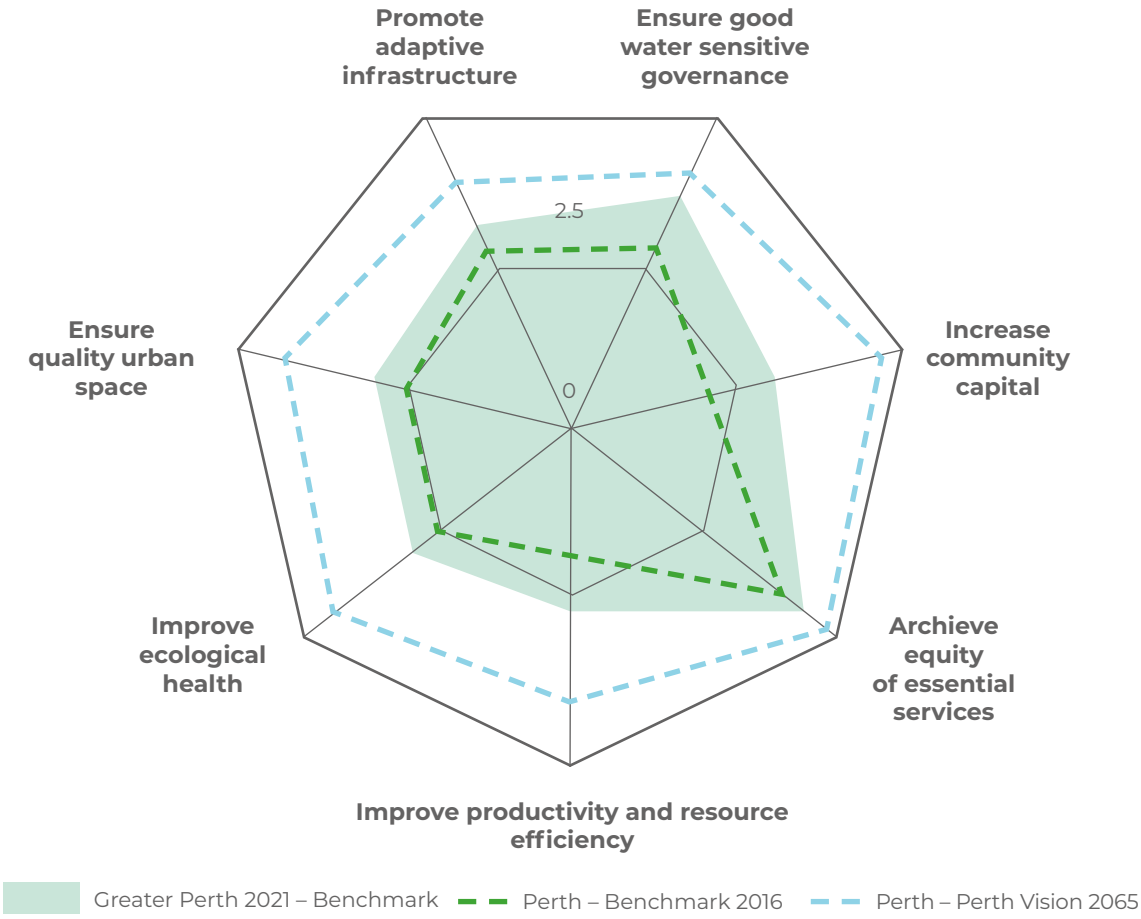


FIGURE 5. RESULTS OF PERTH'S REASSESSMENT USING THE WSC INDEX IN 2021, COMPARED TO THE 2016 BENCHMARK AND 2065 VISION MAPPED TO THE SEVEN GOALS OF THE WATER SENSITIVE CITIES INDEX.

in streamflow into Perth's dams over the last decade compared to the flow received pre-1975. At the same time, Greater Perth's population grew by 150% between 1975 and 2020. Urban sprawl has seen the city expand across a 150 kilometre stretch of the coast, increasing the cost and environmental impact of servicing households. Additionally, the climate - and city - is getting warmer, increasing the demand for water. The average annual number of days above 35°C in Perth is predicted to increase from 28 (1971– 2000 average) to 36 by 2030. To adapt to the impacts of climate change, the sources of Perth's drinking water have changed dramatically over the last 15 years. Perth is an international leader in developing climate-resilient water sources, like seawater desalination and groundwater replenishment, which now make up approximately half of Perth's drinking water. There has also been great success in working with the community to reduce water use in Perth, achieving more than a 30% reduction in water supplied per capita since 2001 (Water Corporation, 2022b). However, Perth has the highest greenhouse gas emissions per property associated with its water services in Australia, and remains one of the highest water using cities in Australia (and, indeed, the world) (BOM, 2021). A key challenge for Perth is how to create and maintain highly liveable communities when natural fresh water

sources continue to decline. Responding to this challenge, Perth stakeholders saw the opportunity to work with Monash University and the CRC for Water Sensitive Cities to undertake a transition to a more water sensitive city.

PROCESS

The application of three novel tools, developed by the CRCWSC, and designed to identify the transformative changes required to achieve the vision for a city's water future have enabled and accelerated progress:

1. An Envisaging process (Rogers et. al., 2021) undertaken in 2015 to develop a shared vision across the diverse stakeholders who shape a city and foster commitment to a strategic transition framework;
2. The Water Sensitive Cities Index (Rogers et. al., 2020) to benchmark Perth's urban water management performance undertaken in 2016; and
3. The Transition Dynamics Framework (Rogers et. al., 2021) undertaken in 2018 to diagnose the presence and maturity of enabling factors required for a city's shift to water sensitive practices

These tools were used with city stakeholders from multiple institutions to create s a Vision and Transition Strategy for a Water Sensitive Greater Perth (Hammer et. al., 2018) and an implementation plan comprising 31 actions and indicators of success. In 2021, Perth became the first city to re-benchmark using the Water Sensitive Cities Index process. Insights from this reassessment are being used to update the Implementation Plan.

OUTCOMES

The water sensitivity of Perth was re-benchmarked in February 2021 (Figure 4). This revealed that Perth has made substantial progress towards a water sensitive city, increasing from 5% in 2016 to 18% in 2021. A notable uplift against the preceding phase, a 'water cycle city', was also recorded – a 22% increase (from 44% in 2016 to 66% in 2021). Similarly to 2016, the goal areas that scored the highest were 'ensure good water sensitive governance' and 'achieve equity of essential services' (Figure 5). These improved scores are reflective of the presence of a long term vision and cross-sector commitment across the metropolitan region including a whole-of-government Waterwise Perth Action Plan (2019). Least progress has been made to 'improve ecological health'; 'ensure quality urban space'; and 'promote adaptive infrastructure, and accordingly, these goal areas were considered to be a focus for strategy development. TDF assessments were undertaken to better understand the practice change needs and the outcomes used to support preparation of the WSTN Implementation Plan for 2021-2024.

PERTH'S STRATEGY

A significant contribution to Perth's improved score is the action undertaken by the 32 Perth and Peel local governments. A major milestone achieved in 2021 was all local governments being endorsed under the Waterwise Council Program (Water Corporation, 2022c), which is a joint initiative between the Water Corporation and

the Department of Water and Environmental Regulation. The Program supports and encourages local governments to continuously improve their water management and adopt water sensitive principles as part of the Program's recognition scheme. Eligible local governments are offered a WSC Index workshop. Since 2016, 20 of the 32 local governments have completed benchmarking workshops which has led them to developing comprehensive water management action plans. Perth achieved notable progress in the following areas of the Index framework:

Goal 1 'Ensure good water sensitive governance', where the political, social, economic and administrative systems are in place to support water sensitive practice. Improvements in this goal area were driven by:

- strengthening cross-sector institutional arrangements including the Water Sensitive Transition Network and high level commitment to cross agency steering groups to deliver the long term vision through development of the WA Government's Waterwise Perth Action Plan. The Waterwise Perth Action Plan was awarded with the Australian Water Award for Organisational Excellence in 2024;
- updates to the water planning framework by streamlining and consolidating six water-related State planning policies and the Government Sewerage Policy into one to deliver greater clarity and guidance around integrating the management of water resources into planning and development decision-making;
- improvements to public engagement and participation through initiatives such as Tap In, Water Corporation's largest and most comprehensive community engagement program and establishment of a reference panel of almost 10,000 customers who provide input and feedback to guide the Corporation's activities;
- establishment of the Groundwater Replenishment Visitor Centre in 2018 which saw more than 11,000 community members touring the site; surveys taken of people who visited the plant indicate support of over 90% once they have an understanding of the processes involved in wastewater treatment and groundwater replenishment;
- an increase in equitable representation of perspectives achieved through organisations' equity and inclusion policies, improvements in diversity of Board members; increase in Indigenous Australians employed in the water sector (4.8% Indigenous Australians employed at Water Corporation in 2021, compared to 3.0% in 2016 (Water Corporation, 2021 & 2016); and progress implementing Reconciliation Action Plans and Aboriginal Engagement Strategies.

Goal 2 'Increase community capital', where citizens have the knowledge and connection to water and are empowered to contribute to decision-making. The increase in this goal area was driven by:

- an increase in connection to water achieved through the award-winning Waterwise Schools Program which reaches over 30,000 students each year. (Water Corporation, 2024) and by community engagement in the Drainage for Liveability Program (Water Corporation, 2022d), which transforms drains and basins to provide greater amenity for the community;
- an increase in community connection to local water assets and stories through Water Corporation's Splash of Colour Program (Water Corporation, 2022e), which

has resulted in over 75 assets transformed into artworks reflecting the importance of water to local communities and ecosystems since the program commenced in 2017;

- success of waterwise messaging and incentives, reflected in the high uptake of water saving measures by customers (e.g. Shower Head Swap Program) and market research finding customers have good knowledge of water saving practices around the house and garden and 90% of survey respondents indicating their household actively tries to save water; and
- COVID-19 restrictions changing people's behaviour and resulting in increased appreciation of river systems, greenspace and gardening.

Goal 4 'Improve productivity and resource efficiency', including low greenhouse gas emissions, low potable water demand, maximised resource recovery and new business opportunities and benefits across other sectors generated through innovation in the water sector. Improvements in this goal area were driven by:

- improvement in managing greenhouse gas emissions associated with the water sector through release of the Western Australian Climate Policy (DWER, 2020) setting targets to transition to a zero net carbon future, investment in clean energy (such as the Water Corporation's $30 million solar program), increased investment in offsets, transitioning vehicle fleets to electric, and local government investment in improving energy efficiency, solar and geothermal energy;
- the success of waterwise programs and targeted initiatives to reduce potable water demand, for example over nine billion litres of scheme water was saved by businesses participating in the Waterwise Business Program in 2019-20, and 100% of local governments in the Perth region achieving endorsement as Waterwise Councils through their commitment to improving water efficiency and creating waterwise communities (Water Corporation, 2021); and
- greater investment in recovering resources from waste streams, including over 20 billion litres of water being recycled as well as reuse of 100% of biosolids produced in Perth in 2019-20, biogas generators at two wastewater treatment plants to produce renewable energy, and exploration of new opportunities to deliver an Australian-first project to produce low-emission hydrogen and graphite from sewage at a wastewater treatment plant.

CONCLUSION

Working with the CRCWSC tools enabled the formation and adoption of a vision of Perth as a leading water sensitive city, consisting of four themes:

1. Fostering stewardship of the system;
2. Protecting and enhancing the wellbeing of people and the environment;
3. Integrating and engaging with the built and natural landscape; and
4. Sustaining the long-term use of Perth's resources.

Application of the three novel tools between 2015 and 2024 achieved:

- Establishment and growth of a community of practice, called the Water Sensitive Transition Network – a group of champions from across government, industry, community and research organisations working together to transition Perth to a water sensitive city.
- Co-investment by stakeholders to deliver key projects designed to address priorities identified under the Vision and Transition Strategy for a Water Sensitive Greater Perth (2018), including projects to increase understanding of Aboriginal knowledge to inform land and water planning; effective community messaging to influence water knowledge and behaviours; and maintenance and life cycle costs of water sensitive systems.
- Increased collaboration and coordinated action across Government, leading to the development of the Western Australian Government's Waterwise Perth Action Plan (2019), which has been followed by a second plan (2022) and third action plan to be launched in October 2024. This program is the first time key government agencies across water, planning, environment, transport, community and development portfolios have committed to working to achieve the shared vision of Perth as a leading water sensitive city (referred to as a waterwise city in Western Australia).
- A 26% improvement in Perth's overall performance assessed using the Water Sensitive Cities Index tool, compared to when the city was benchmarked five years previously.

These key changes in culture, governance, planning and practice are working to transform urban development and water system management in Perth. Shifts in leadership – from individual activists through to senior executive networks – championing the change to water sensitive practice have occurred over the last 30 years, but most notably in the last nine years, supporting the state government to sustain a more enabling authorising environment. Through increased collaboration and collective action across many stakeholders, Perth is well on its way towards its vision of being a water sensitive city.

REFERENCES

- Bureau of Meteorology (BOM) (2021) *National performance report 2019–20: urban water utilities, part A*. Melbourne, VIC, Australia. http://www.bom.gov.au/water/npr/docs/2019-20/National_Performance_Report_2019-20_urban_water_utilities.pdf
- Briony Rogers, Alex Gunn, Katie Hammer, Chris Chesterfield. (2021) *An enhanced WSC visioning and transition planning methodology Water sensitive city visions and transition strategies (IRP1) Melbourne*, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Department of Water and Environmental Regulation. (2020), *Western Australian Climate Policy, A plan to position Western Australia for a prosperous and resilient low-carbon future*. URL: Western_Australian_Climate_Policy.pdf (www.wa.gov.au). Accessed: 13 September 2024.
- Department of Water and Environmental Regulation. (2019), *Waterwise Perth, Two Year Action Plan*. URL: Waterwise-perth-action-plan.pdf (www.wa.gov.au). Accessed: 13 September 2024.
- Department of Water and Environmental Regulation. (2022), *Kep Katitjin – Gabi Kaadadjan Waterwise Perth Action Plan 2*. URL: KEP-Katitjin-plan-21102022.pdf (www.wa.gov.au) Accessed: 13 September 2024.
- Gunn, A. W., Werbeloff, L., Chesterfield, C., Hammer, K. and Rogers, B.C. (2017). *Vision and Transition Strategy for a Water Sensitive Adelaide*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Hammer, K., Rogers, B.C., Gunn, A., Chesterfield, C. (2020). Transitioning to water sensitive cities: insights from six Australian cities. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Hammer, K., Rogers, B.C. and Chesterfield, C. (2018a). *Vision and Transition Strategy for a Water Sensitive Greater Perth*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Hammer, K., Rogers, B.C., Gunn, A., Church, E. and Chesterfield, C. (2018b). *Vision and Transition Strategy for a Water Sensitive Greater Sydney*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Hammer, K., Rogers, B.C., Chandler, F. and Chesterfield, C. (2018c). *Vision and Transition Strategy for a Water Sensitive Townsville*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Rogers, B.C., Dunn, G., Hammer, K., Novalia, W., de Haan, F.J., Brown, L., Brown, R.R., Lloyd, S., Urich, C., Wong, T.H.F., Chesterfield, C. (2020). *Water Sensitive Cities Index: A diagnostic tool to assess water sensitivity andguide management actions*. Water Research, https://doi. org/10.1016/j. watres.2020.116411
- Rogers, B.C., Chesterfield, C., Brodnik, C., Church, E. and Hammer, K. (2017). *Vision and Transition Strategy for a Water Sensitive Gold Coast. Report for the City of Gold Coast*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.
- Rogers, B.C., Gunn, A., Church, E., Hammer, K. and Lindsay, J. (2018). *Vision and Transition Strategy for a Water Sensitive Bendigo*. Melbourne: Australia: Cooperative Research Centre for Water Sensitive Cities.
- Water Corporation (2016) *Engaging with the community: 2016 annual report*. https://www.watercorporation.com.au/About-us/Our-performance/Annual-report
- Water Corporation (2021) *Water Corporation Annual Report 2021*. https://www.watercorporation.com.au/About-us/Our-performance/Annual-report
- Water Corporation (2022a) *Climate change and WA*. https://www.watercorporation.com.au/Our-water/Climate-change-and-WA
- Water Corporation (2022b) *Water Use*. https://www.watercorporation.com.au/Our-water/Rainfall-and-dams/Water-use
- Water Corporation (2022c) *Waterwise Council Program. https://www.watercorporation.com.au/Help-and-advice/Waterwise-business-programs/Waterwise-Council-Program/About-our-program*
- Water Corporation (2022d) *Drainage for Liveability Program*. https://www.watercorporation.com.au/Our-water/Sustainability-and-innovation/Drainage-for-liveability
- Water Corporation (2022e) *Splash of Colour Program*. https://www.watercorporation.com.au/About-us/In-the-community/Splash-of-Colour

ROMAN ZHEBCHUK

CHERNIHIV (Чернігів)

Population: 282,747
Area: 79 km²
Population density: 1,547/km²

ABOUT THE CITY

Chernihiv is a city and commune in northern Ukraine and is the administrative centre of the Chernihiv oblast and district. Flowing through the city is the Desna river, the main left tributary of the Dnieper river. Chernihiv lies approximately 60 km from the border with Russia and Belarus

On 24 February 2022, Russia launched a full-scale invasion of Ukraine. Russian troops approached the city, but, unable to capture it, began indiscriminate shelling of its civilian infrastructure using aviation and artillery.

On 06 March 2022, the President of Ukraine, so as to honour the heroism and determination of citizens who defended their city against the armed aggression of the Russian Federation, awarded Chernihiv the honorary title “Hero City of Ukraine”.
On 22 March, after three weeks of continuous shelling, the city was on the brink of a humanitarian catastrophe. On the night of 22-23 March, as a result of Russian bombing, the road bridge across the Desna (as shown in Figure 1), which connected the

city with Kiev and the whole of Ukraine, a “road of life” for residents of the besieged Chernihiv, was destroyed, thus significantly worsening the situation. In the city, there was no electricity, while water, gas and communication severely limited *[Siege of Chernihiv,* https://en.wikipedia.org/wiki/Siege_of_Chernihiv *, 26.09.24, 17:00].*
Until April 2022, the city remained under siege, with Russian troops endeavouring to enter the city. All attempts were successfully repelled by the brave defenders of the hero city. Yet, nothing could be done against frequent shelling and bombing.
As of 3 April 2022, shelling of the city ceased, and humanitarian aid began to be delivered.
While at the moment the city is not under temporary occupation, it is experiencing some of the most difficult moments in Chernihiv’s history. The city has become one of the most destroyed cities in Ukraine in the full-scale invasion of the Russian Federation. According to the city mayor, some districts were 70% destroyed.
At the same time, the threat from the aggressor is ongoing, not only in the form of bombings, but also in another way - through pollution of waterways.
Yes, on 14 August 2024, the Russians caused massive pollution of the Sejm river, that is the main tributary of the Desna river. The results of hydrochemical analysis of water samples from the Sejm river showed exceeded permissible concentrations of pollutants, including ammonia and suspended substances.

https://www.slovoidilo.ua/2024/09/10/novyna/suspilstvo/zabrudnennya-richky-desna-voda-skoro-mozhe-dosyahnuty-kyyivshhyny

As a result of river pollution, mass fish deaths occurred due to the critically low concentration of oxygen dissolved in the water (below 1 mg/l with the minimum permissible standard of 4 mg/l), caused by the processes of its biochemical consumption by organic substances which entered the aquatic environment. *[Екологічна катастрофа на Сеймі: російські окупанти отруїли річку,* https://darg.gov.ua/_ekologichna_katastrofa_na_0_0_0_13887_1.html?fbclid=IwZXh0bgNhZW0CMTAAAR0vYWK0SfL82ZwiibMZO5wRguz_TnHaLkeBXNyGYc8yx2qFF0q1I2QBUZE_aem_JJuS5V-OVT8LRRwURFtixg*, 26.09.24, 17:00].*
According to experts, about 5.7 thousand tonnes of sugar processing products ended up in the water. The water in Desna became cloudy and massive fish deaths were reported in places. In total, approximately 17.5 tonnes of dead fish were collected in the Chernihiv region.

Preliminary expert assessments show that the restoration of biodiversity and biological resources of the Sejm and Desna rivers will take at least 2-3 years.
In the context of the above description, there can be distinguished several elements of the water management system which contributed to the survival and reconstruction of the residents of Chernihiv in these difficult times.

CASE STUDY

1. Water autonomy of Chernihiv

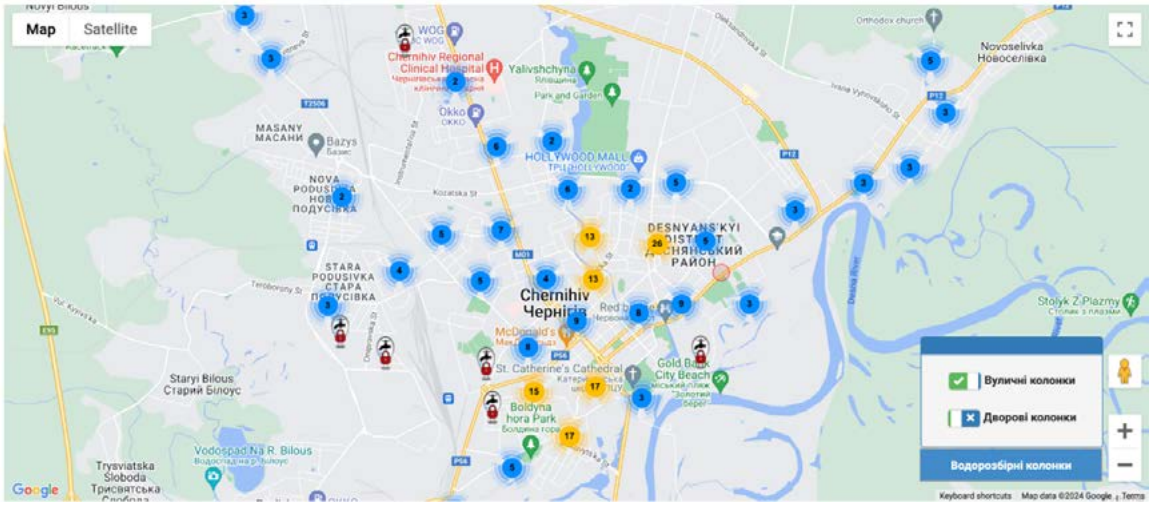
Chernihiv is one of the few cities in Ukraine where residents can drink water straight from the tap. The natural quality of water is stems primarily from the fact that water is sourced from artesian wells, the depth of which ranges from 81 to 750 metres. Physicochemical and biological indicators of the well water show that it does not require additional treatment. The Desna river could also serve a source of water supply for Chernihiv.
In 1879, when the issue of water supply for the city of Chernihiv was being considered, on the recommendation of the Kiev Waterworks Society, a project was drawn up to supply the city with water from the Desna river upon further treatment. When considering the project in the city council, councilor A.P. Karpynskyi proved that spring water is better than river water. At his proposal, the council decided to use underground intakes in the Yalivshchyna region (Yalivshchina). From this moment, in 1880, the history of the central drinking water supply of the city of Chernihiv began *[Чернігів – одне з небагатьох міст України, де і сьогодні мешканці можуть пити воду прямо з-під крану, https://chernigiv-rada.gov.ua/news/id-46273/ , 26:09.24, 17:00]*.
Currently, water supply and sewage disposal from the city of Chernihiv is provided by the municipal enterprise “Chernihiv Waterworks” (“Чернігівводоканал”) of the Chernihiv City Council.
The source of water supply for the city of Chernihiv is the Chernihiv fresh groundwater deposit. The water supply for the city of 300,000 inhabitants is provided by 5 group water intakes and 6 separately located municipal artesian wells. Water is extracted from ground levels - Senomanian-Lower Cretaceous and Bukhara. The total number of artesian wells is 109. Of this number, 65 wells are suitable for water abstraction: 32 wells from the Senomanian-Lower Cretaceous level, and 33 wells from the Bukhara level.
The use of groundwater as a source of water supply helped Chernihiv survive both through the siege and following the poisoning of the Desna river. Today, the system is being rebuilt, with an emphasis on pump stations and water supply routes to the city’s residents.
At the same time, an interesting practice currently put in use, supporting the city and strengthening its “water autonomy”, is the packaging of drinking water [Питна водна у Чернігові: якість, пакетування, артезіанські свердловини https://suspilne.media/chernihiv/518587-pitna-vodna-u-cernigovi-akist-paketuvanna-artezianski-sverdlovini/]. This approach assumes creating supplies of drinking water in packaged form. Such stocks are used in case of emergencies. Everyone who stayed in Chernihiv during active combat operations (February-March 2022) well understands the meaning and value of water.
Another aspect is the need to provide water to the private sector in the event of temporary halt of water supplies. In Chernihiv, there are about two hundred houses in pri-

vate development which require water supply when necessary, and water packaging is one of the solutions to this situation. The quality of packaged water is checked daily: water samples are taken and the composition of all minerals is examined. Research is currently being carried out to determine the maximum shelf life and best storage conditions.

2. Water “decentralization” of the city

In order to ensure the supply of water, city residents actively use both their own wells and municipal water intake points - manual garden water pumps. This approach increases the water supply capacity during urban emergencies. Today in Chernihiv, 792 house owners (or 1,296 citizens, officially registered in these houses) receive water from street intake points. The total number of water intake points is 251. This number is increased by another 1,483 so-called “backyard” points - these are manual garden water pumps, located on private property. Backyard points in Chernihiv are used by 2,693 house owners, or 4,308 citizens, officially registered in these houses. [«Операція колонка» – триває, https://water.cn.ua/news/operatsiya-kolonka-trivae_450, 26.09.24 18:00].

The city also has an interactive map of such water intake points, thus availing information to city residents [https://water.cn.ua/map-column]:



As part of the municipal water supply system, such urban intake points are used by the municipal water supply company in order to reduce debts related to defaulting on payment for central water supply and sewage disposal services on the basis of the regulation, “On measures to ensure timely billing of consumers for services provided by the Chernihiv municipal water supply company“. This applies only to those debtors whose debts for the services of central water supply and/or central sewage disposal span longer than three months, with there being a final court decision to collect the debt. This means that, at first, the company applies all other possible methods of influence against debtors, and only then – it resorts to this manner of debt collection. Settlements with such debtors will also be transformed into the standards provided for users of water from street water intake points [Тільки до водорозбірної колонки: у Чернігові придумали новий спосіб постачання води злісним боржникам, https://val.ua/site/114918, 26.09.25, 18:00].

3. The city of Chernihiv - a “water rescue” for the capital.

Today, 60% of water intake for the preparation of drinking water and its supply to the central water supply system of the capital of Ukraine - the city of Kiev, is made from the Desna river *[Щодо якості питної води,* https://www.vodokanal.kiev.ua/shho-do-yakosti-pytnoi-vody*, 26.09.24, 18:00]*.

Chernihiv is the largest city along the Desna-Dnieper road, which creates natural conditions for city cooperation in water management, especially in crisis situations – as described above.

Yes, on its own initiative, “Chernihiv Waterworks” abstracts water from the Desna river within the city limits three times a day for the purpose of running laboratory tests and assessing its contamination level. As part of such tests, there were found increased levels of nitrogen, iron, manganese, and oxygen deficiency. In order to combat pollution, the company developed and installed its own water aeration plant in the Desna river.

Taking into account the effectiveness of this method, “Chernihiv Waterworks” transferred the plans of its development to the Dniester Basin Directorate of Water Resources and offered technical assistance in the production of similar systems to be used in other towns along the river [Ситуація із станом річки Десна в межах міста покращилася, https://chernigiv-rada.gov.ua/news/id-163011/ , 26.09.24, 19:00].

In such way, the city keeps improving the quality of water resources while helping to monitor and improve the quality of water flowing to the capital. This opens up opportunities for expanding cooperation between cities in mutual development of water management approaches.

SUMMARY

Water autonomy: Chernihiv’s water supply model, based on artesian wells, provides high-quality drinking water without additional treatment. This may be useful for Polish cities which strive to provide residents with safe water, especially in extreme situations.

Water Packing: The practice of water packaging in Chernihiv acts as a quick response to emergencies. Polish municipalities can implement similar systems to ensure water supplies to the population in crisis situations.

Decentralization of water supply: The use of street water intake points and private wells in Chernihiv provides additional water sources. This could be implemented in Polish cities to increase water availability, especially in areas with insufficient central water supply.

Cooperation between municipalities: Chernihiv actively cooperates with Kiev in monitoring water quality, which highlights the importance of regional coordination. Polish cities can develop partnerships with a view to exchanging experiences and technologies in water management, thus increasing the overall level of water security.

Innovative solutions: Introduction of aeration systems in Chernihiv aimed at improving water quality may serve as an example for Polish cities struggling with similar water pollution problems, for example in the Oder river basin. Technological solutions which have proven their effectiveness can also be adapted in other communities.

MONIKA WOJCIECHOWSKA,
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KUOPIO Finland

Population: 122,500
Area: 2,317 km²
Population density: 66 people / km²

Photo 1. View of the Kuopio city from the Puijo tower. Author: Monika Wojciechowska

ABOUT THE CITY

Kuopio is a city and commune in central Finland, in the Northern Savonia (Pohjois-Savo) region, located on the huge Kallavesi lake, which forms part of the identity of the city and the Savo region inhabitants. The total area of the commune is 3,740 km², of which approximately 25% is water. The area is inhabited by 122,500 people (at the end of 2022). The city and the surrounding area are called the Blue Pearl of the Finnish Lake District.

In 1775, King Gustav III of Sweden ordered the founding of the city of Kuopio, and this date is now considered the city's official founding date. Kuopio was granted city rights in 1782, while a few years earlier, in 1778, there had already been established a school. In 1844, a secondary school was established, and at the end of the 19th century, there were founded industrial, commercial, and nursing schools. In 1966, founded in the city was a university and to this day higher education has remained the key aspect of the city's development [1,5].
Interestingly, since the 19th century, Kuopio has played a significant role in the development of Finnish sports. Due to the large differences in terrain (the difference in altitude ranges from 81 to 311 m above sea level - author's note), located in the heart of Kuopio, on the Puijo hill, is the Puijo ski jumping complex and the tower of the same name (Puijon torni). There are four ski jumps here. All facilities are equipped with artificial lighting and plastic mattings (in the 1970s, the facility was equipped with a mat enabling jumping in summer). Ski jumping was carried out on the hill as part of the World Cup from the 1994/1995 season to the 2015/2016 season (with breaks in the years 2002-2003 and 2011-2012) [2,3].

Photo 2. (left side) View of the Kuopio Museum building, (top right) View of the ski jumps on Puijo Hill, with the Puijo Tower in the background, (bottom right) View of the Kallavesi Lake embankment towards the Kuopio Passenger Port (Kuopion matkustajasatama). Author: Monika Wojciechowska

The largest lake in the Northern Savonia region extends around the town of Kuopio with its coastline spanning 5,442 km. The Kallansillat Bridges on National Road 5 divide the lake into two parts: North and South Kallavesi. The lake forms the large, labyrinth-like Iso-Kalla water complex, along with basins having the same water level: Juurusvesi, Muuruvesi and Riistavesi, and the third deepest, crystalline crater lake Suvasvesi, whose total area is 890 km^2. Lake Kallavesi is covered with numerous islets. The varied coastline is partly rocky and raw, but sandy beaches and marshy coves also abound [4,5].

Kuopio is surrounded by forests, which encroach on its outer districts, shaping its housing in a truly interesting manner, making it resemble holiday resorts in high season - inhabitants are surrounded by trees, while the view of the open water of the lake is an additional attraction. To the north of the Puijolakso district, there are forests classified as parks, open spaces, recreational, landscape and shelter forests, and nature reserves. The Puijo Trail runs through a nature reserve, and along the trail there are panels depicting the area's wildlife, luge, Puijo Tower, cultural figures related to Puijo, and other cultural history facts. [6]. The Lavvu Puijonnokka shelter located on the trail is a wonderful cultural phenomenon - a typically Finnish free-standing structure made of wooden logs open on one or more sides (laavu, colloquially called an annex, even though it is not attached to anything), with a fireplace ready for use and a wooden outhouse nearby, used as a shelter by tired tourists.

WHAT MAKES THE CITY AN EXEMPLARY ONE

The combination of raw nature, lake waters, and active leisure regardless of the weather is what the city of Kuopio has to offer to residents and tourists. Bringing together companies and key people from the region operating in the water sector in one place – that is, in the water cluster - is another solution worth noting and following. The permission granted by the city authorities to use for scientific purposes a portion of the city's existing water supply, sewage, stormwater, and lake infrastructure to test university facilities or institutional research projects is also worth copying.

WATER WILDERNESS OR VIBRANT LAKE SHORES

Description of the model solution

The city of Kuopio takes full advantage of its natural surroundings, characterized by extensive waterways with winding coastlines and lush vegetation, as well as varied terrain with many hills. The city surrounded by Lake Kallavesi and the diverse Puijo area, valuable deciduous forests, and ponds in various parts of the city are among Kuopio's most famous natural features. The abundance of watercourses and extensive forest areas provide good opportunities for recreational use of the natural surroundings. And so, recreational trails and nature trails can be found all around Kuopio. A wide network of exercise trails is used both in summer and winter, especially in the Puijo area - for various types of sports activities: from outdoor gyms, to disc golf courses hidden in the forest, cycling, hiking, and running trails, where cross-country runs and marathons are organized, and in winter, there are downhill or cross-country skiing trails, as well as dog parks. Thanks to its clean environment, the Kuopio area is ideal for picking berries and wild mushrooms, but one should not overlook Lake Kallavesi, famous for its excellent fish [5]. The real treasure of Lake Kallavesi is the water area of some 40 km², located to the south of the lake, and especially the uninhabited archipelago of islets scattered in its central part. This area was once given to the city of Kuopio by the King of Sweden. But it was the long-sighted planning of the city authorities that contributed to preserving the area between the islands of Iivarinsalo and Vatanen as a free area, available to

anglers and delighting the nature lovers. The basic equipment for visitors includes fishing shelters, outbuildings (laavu), and food preparation stations. The coastline of the islets is jagged and rocky. Near the rugged islands of Koisti and Miettie, the water level drops rapidly to 40-50 metres. A trolling fishing method proves ideal in the waters of the archipelago. Kallavesi is also a favourite for boat, ship, and jet ski tours. Boats depart from Kuopio for cruises on the lake. In summer one may go by boat to the town of Savonlinna. Located on the southern edge of the lake is the largest lake island, Soisalo [2].

Photo 3. (left side) A path from Puijonsarvi towards the Kokonmäki-Satulanotko hill – the Puijo trail, (top right) Puijonnokka – a viewing platform, (bottom right) Puijonnokka – an annex shelter (Puijonnokka Laavu). Author: Monika Wojciechowska

The lake shore makes up a part of the Kuopio's city centre, with its developed infrastructure for mooring ships, yachts, motorboats, jet skis, boats, even a water plane offering flights over the picturesque area. Restaurants are abound on the water and on ships - both those moored and those offering courses on the lake with guides telling the stories and curiosities of Lake Kallavesi (the Vuoksi river basin, the largest in Finland, connects the lake with lakes Saimaa and Laatoka, and finally, with the Baltic Sea). In winter, when the lake's frozen surface is thick, one may travel thereon by cars, snowmobiles, but also on cross-country skiing and skating trails, as well as take walks to the nearest islands, which are not easily accessible in summer.

Photo 4. View from the route of the frozen Kallavesi lake towards the bridge on the Honkasaarentie road. Author: Monika Wojciechowska.

In the city centre, there are also several hotels near the waterfront offering relaxation, a Finnish sauna, and tennis and padel courts. The life of residents and visitors centres around the city's coast – there are organized fairs (e.g. an annual wine fair) and thematic fairs, especially flea markets. Residents love spending time in the closeness of water and this very lifestyle is also recommended by the city authorities. There are beaches scattered throughout the city in various spots, and each larger beach has toilets and changing rooms. There is also the Väinölänniemi city beach with all catering infrastructure, toilets, showers, and the swimming pool

Photo 5. (top left) South viewpoint at Väinölänniemi, (bottom left) mooring point near Niuva Beach (Niuvan uimaranta), view of Hapelähde Park near Kuopio Passenger Port, (right side) Kuopio Passenger Port (Kuopion matkustajasatama). Author: Monika Wojciechowska

formed in the lake even has its diving tower in a deeper place. The climate of Kuopio is definitely more severe than that of Helsinki - the city is about halfway between the capital and Rovaniemi, far to the north, the famous hometown of Santa Claus, which means that summers in Kuopio are short but very sunny, and that there occur white nights (from the famous Juhanus festival in Finland, heralding the beginning of summer to the end of July). The city's concern lies in ensuring that residents spend as much time outdoors as possible, and one may say it is actually rooted in Finnish culture. Here, the image of mothers accompanying children on the playground on a rainy day, or children spending every school break outdoors, where their voices are heard outside just as loud on sunny days as they are on bad weather days, does not surprise anyone.

Possibilities of implementing the solution

Any city with a lot of green areas and surrounded by various types of water stands a chance, like Kuopio, of taking advantage of the abundance of watercourses and vast forest areas surrounding it, thus creating good opportunities for recreational use of the natural surroundings. This relatively small commune proves with its solutions that it is not always necessary to clear forests and regulate shorelines of rivers and lakes in order to create infrastructure for environmentally friendly recreation, free water resources at the disposal of anglers, sailors and nature lovers, with basic equipment hidden in the forests, such as solitary shelters, wooden shelters, along with meal preparation stations and natural wooden outhouses. Organizing nature-based sports events, such as cross-country running or cycling on wild forest paths just like kayaking in natural parks, is characterised by a single feature - uncertainty as to natural conditions (every year, trees break in different locations, similarly, wild animals are present elsewhere), which means that, year on year, one may follow the same trail in a different way .

The second way in which Kuopio uses the potential of the lake in the city is centering services – related to water, hotels, restaurants, excursions, and the like, in the regulated parts of the lake shore in the heart of the city, thus offering a water architecture conducive to organizing events, inviting sailors to sail and moor in the port, and travelling around the lake for tourist purposes. However, while the second solution is undoubtedly the most widespread and used in many cities having water potential, it is the first purpose that appears much more unique and requires an individual approach to ensure that remote places maintain their character, but at the same time are popular tourist spots.

Such hybrid use also has already been applied in Poland – to name but one example, Szczecin, which has also used in a similar way the potential of its huge natural water resources (rivers, lakes, and connections between them, up to the Szczecin Lagoon and the Baltic Sea) and the forest areas surrounding the city and encroaching thereon.

WATER KNOW-HOW SUPPORTED BY THE CITY

Description of the model solution

A city boasting such great water potential should undoubtedly bring together water and nature institutions and institutions caring for a low-emission and resource-efficient economy in the region with a view to scientific development and conducting broadly understood water research. This possibility is provided by the created water sector cluster called Kuopio Water Cluster (KWC). The cluster uses the potential of its five founding members:

- Savonia University of Applied Sciences - expert in SmartWater technologies and zero-emission industry - science and research,
- UEF University of Eastern Finland - expert in water chemistry - science and research,
- GTK, Geological Survey of Finland (Finnish Geological Survey) – expert in water management and monitoring – public research institute,
- LUKE, Natural Resources Institute Finland – expert in sustainable use of natural resources – public institution, scientific research,
- THL, Finnish Institute for Health and Welfare - expert in risk management and microbiology - public institution, scientific research,

in order to merge the Finland's network of local universities and multidisciplinary national research institutes focused on the water sector into one research, development, and innovation ecosystem.

Research cooperation in the water sector is assumed to have started in Kuopio in the 1980s, when the then KTL (then National Institute of Health, now THL) and the University of Kuopio (now UEF) commissioned research on by-products of drinking water disinfection. The research resulted in international publications, as well as, among others, largely updated disinfection recommendations for the Finnish water supply sector. In addition to research activities, KTL and the university also cooperated within the field of teaching, supervision of students' master's and doctoral theses, as well as cooperation in the implementation of chemical and then microbiological analyzes in cooperative projects conducted by the University of Kuopio.

In the 1990s, research and teaching cooperation between KTL and the university was already in full swing. The year 1992 saw the founding of the Pohjois-Savo University of Applied Sciences (now Savonia). At the same time, construction of the Technopolis Kuopio campus, i.e. the former Teknia Oy, began along the Savilahdentie city road. The city played an active role in supporting development of activities of companies cooperating with Teknia. The use of EU structural funds for development activities took a dynamic turn after Finland's accession to the European Union in 1995. In 1998, there was established a study programme in environmental technology at the Pohjois-Savo University of Applied Sciences. The main part of the study programme focused on the field of water technology and municipal technology, supplemented, among others, with: air protection technologies and waste management. The first phase of the Microkatu project (the name of the project taken from the name of the street where the University of Savonia is now located) was completed in 2001. The Savonia Water Laboratory (today called WaterLAB) began operating in these facilities

in the so-called laboratory shared with the UEF university and KTL. Launched were the first joint projects of these three organizations, thus forming the basis for future project cooperation. At the same time, cooperation with the UEF university in the field of laboratory classes began at the Savonia Water Laboratory.
The year 2010 saw the project boom begin and structural funds being effectively used - the search took off, cooperation was intensified, and the role of the regional association was strengthened. At the same time, the Savonia University of Applied Sciences took on the role of a practical driver of regional development. Savonia's strategies happened to be in line with a regional development programme that was planned and adapted to the needs of various stakeholders. The cooperation would determine specialization of the province, which applied guidelines of the province's programme and was strengthened by channelling funds for regional development. ERDF funding strengthened selected areas of expertise and the ability to develop them. The GTK and Luke Institutes were also more closely involved in cooperation in the water sector. Collaborative projects were common and some of them also included the content aimed at developing networks and growing cluster cooperation. The culmination of this development occurred in 2018, when, under the auspice of the University of Savonia, an application for funding for the Kuopio Water Cluster project was drawn up. It had been preceded by the so-called preparatory financing, which had enabled, among others, benchmarking of European and North American water competence centres and study visits to selected locations, e.g. in the Netherlands and Norway. On their basis, the structure of the water cluster in Kuopio and the goals of its start-up phase were outlined. The Kuopio Water Cluster project received funding in 2019.
Since 2020, the cluster's activities have been consolidated. The Kuopio Water Cluster project enabled coordinated construction and further development of a large-scale ecosystem. In addition to the founding members (initially 6 of them), the cluster also included corporate members interested in using the cluster network to support activities related to entering the market, creating a cooperation network for start-ups, small and medium-sized enterprises and large companies so as to stimulate growth and innovation – by spring 2022, their number increased to 60 entities (currently there are over 70). The funds from the investment in the cluster project were allocated for strategic investments in equipment, which significantly developed the cluster's capabilities in the field of applied research and product development. Test and pilot activities as well as business cooperation make up the core of the cluster's practical activities. The aim is to satisfy the needs of companies operating within this field and to solve, among others: water-related challenges, particularly from water-intensive industries (e.g. nearby pulp and paper industry). The cluster has been slowly gaining popularity and critical mass, and has also become sough-after partner in international funding applications. In spring 2021, the cluster received ECCP approval. At this stage, KWC has been the first Finnish water cluster to hold official cluster status at EU level [7].

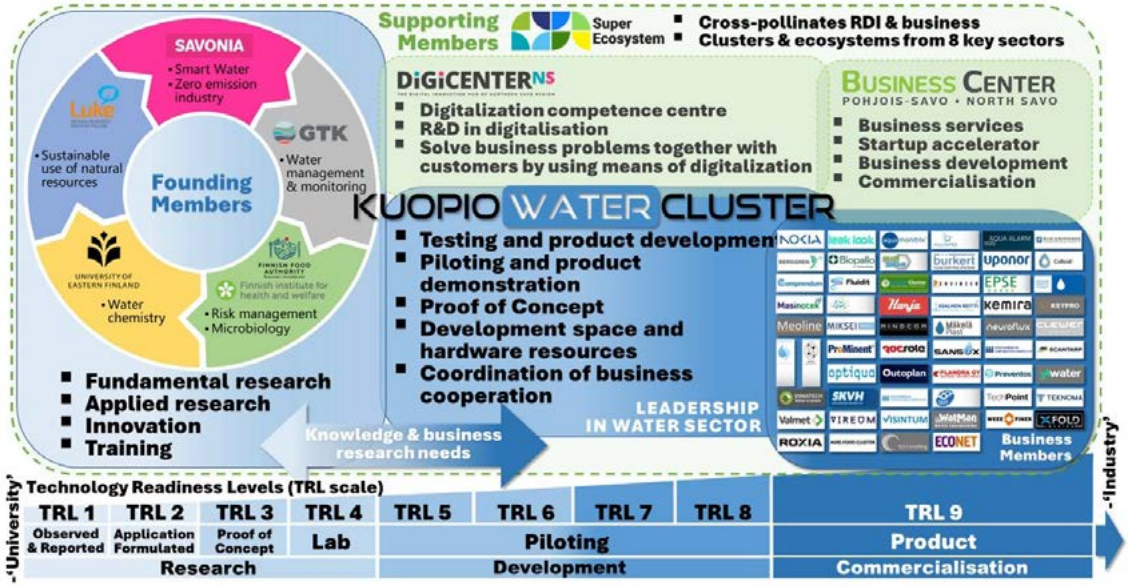


Fig.6. Kuopio Water Cluster flowchart on a technology readiness scale from TRL 1 to TRL 9, from a network of local universities and multidisciplinary national research institutes in Finland, founding members, to corporate members - all stakeholders focused on the water sector within a single ecosystem of research development and innovation. Author: Monika Wojciechowska, Savonia UAS, WaterLAB.

Possibilities of implementing the solution

Finland is surrounded by a huge amount of lake water, but it has great respect for activities aimed at saving natural water resources, bearing in mind water shortages in other countries. Hence the active involvement of the city of Kuopio in such an important topic as creation of a platform providing services in the field of development, testing and commercialization of products, which offers the widest TRL 1-9 range of the technological readiness scale (services on the technological readiness scale from TRL 1 to TRL 9, where TRL = Technology Readiness Levels).

There are two recommended ways of implementing the solution: for cities that are surrounded by large natural water resources, for the purpose of bringing together water and nature institutions interested in creating a common regional development strategy so as to use these resources and develop infrastructure, and for municipalities with high water consumption industries, most interested in a low-emission and resource-efficient economy of the region. The water cluster in Kuopio brings together both groups of interested parties, because in addition to being surrounded by huge amounts of lake water, it also has an industry that uses these resources for its own purposes (pulp and paper industry).

But it does not need to be the creation of a cluster or association from scratch; if they are already operating in the region, it is important to join in with institutions and entities operating in the commune focused on innovation, development, and research, thus increasing the scope of matching scientific partners and enterprises which cooperate in the provision of product testing and commercialization services. The example of Kuopio Water Cluster shows that such association can move from a local dimension to a national or even international one. This certainly works to the advantage of the city itself, which gains recognition, and increases its potential for dynamism.

USING THE CITY'S EXISTING WATER INFRASTRUCTURE TO CONDUCT SCIENTIFIC RESEARCH

Description of the model solution

The city of Kuopio offers to universities and research institutions the use of its own existing underground infrastructure so as to facilitate conducting scientific research and testing of devices implemented in innovative projects, in the form of access to parts of the network, such as water supply, sewage and stormwater networks, as well as the surface intake from the lake. An example of such use is a full-scale measurement area demonstrator called SuperDMA in Kuopio, used by the Kuopio-based Savonia University of Applied Sciences. The Smart Water Technologies Demonstrator, managed by the Department of Environmental Engineering at Savonia University of Applied Sciences, allows for rapid scale-up from the laboratory, pilot, and long-term testing and demonstration of the product in a real environment. The demonstrator is located in Kuopio, in the Savilahti district (right next to the university campus of both Savonia UAS and UEF). It is part of the water distribution system operated by the local waterworks (Kuopion Vesi), surrounding the WaterLAB laboratory of which it is part. Savonia also enjoys the possibility of using Lake Kalavesi as a water intake for powering a water distribution system simulator called WaterLOOP, used for advanced experiments and scenario-based tests. The WaterLOOP system is located in the WaterLAB laboratory - this pilot water supply facility covers nearly 1 km of pipelines (ring and branch network), with its own water intake, multi-chamber water tank

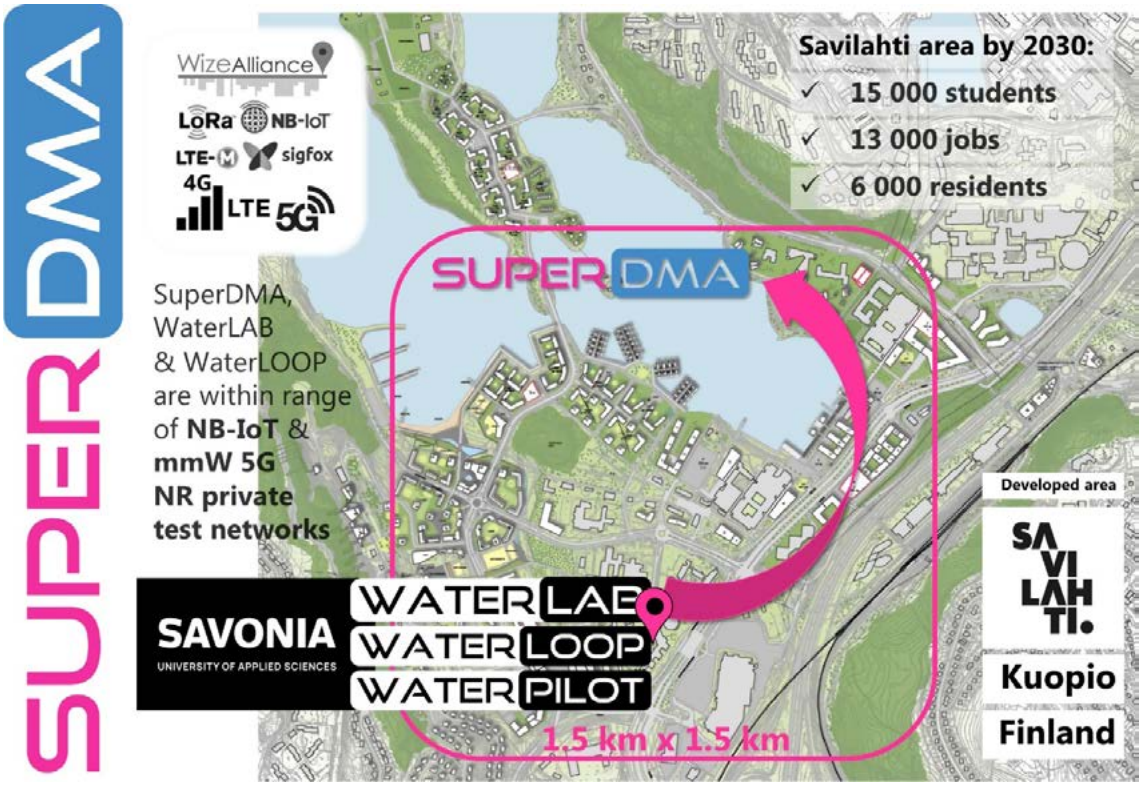


Fig.7. Demonstrator in a full-scale metering area called SuperDMA (where DMA = District Metering Area) with access to parts of water, sewage, and stormwater networks and a surface intake from Lake Kallavesi in the Savilahti district of Kuopio. Author: Monika Wojciechowska, Savonia UAS, WaterLAB.

(approx. 7 cubic metres), first and second stage pumping station and a double system sewage. SuperDMA and WaterLOOP monitoring are within the reach of private NB-IoT and mmW 5G NR test networks which transmit and integrate data in a SCADA programme managed by WaterLAB. It offers various IoT devices with real-time monitoring, guidance and notification tools.

Possibilities of implementing the solution

The possibility of implementing the solution is not limited to any specific city - it can be implemented in any town which has underground water, sewage, and stormwater infrastructure, or surface and underground water intakes. The key element is the motivation to cooperate to be displayed by various scientific and university institutions and the city or water supply and sewage company, thus enabling implementation of projects and development of the city and the region towards the so-called Smart City in the field of the water sector. The win is mutual - scientific institutions and universities gain places to conduct measurements in a real environment during implemented projects, and the city gains monitoring of a part of the water supply, sewage, stormwater and any other infrastructure related to water, the research results of which can also be used by the city for the purpose of, e.g. preventing water leaks and reducing own costs or those of a water supply and sewage company, which is often co-owned or 100% owned by the commune.

BIBLIOGRAPHY:

[1] Kuopio. Wikipedia. Wolna encyklopedia. https://pl.wikipedia.org/wiki/Kuopio, [dostęp: 04.08.2024, 20:35.

[2] Puijo. Wikipedia. Wolna encyklopedia. https://pl.wikipedia.org/wiki/Puijo, [dostęp: 04.08.2024, 21:00].

[3] Puchar Świata w skokach narciarskich w Kuopio. Wikipedia. Wolna encyklopedia. https://pl.wikipedia.org/wiki/Puchar_%C5%9Awiata_w_skokach_narciarskich_w_Kuopio, [dostęp: 04.08.2024, 21:00].

[4] Fishing in Finland. Przewodnik dla wędkarzy podróżujących po kraju tysięcy jezior. https://www.fishinginfinland.fi/pl_kallavesi, [dostęp: 04.08.2024, 20:35].

[5] Kuopio. https://www.kuopio.fi/en/city-of-kuopio/organization/history-of-kuopio/, [dostęp: 10.08.2024, 20:35].

[6] Puijo Path. AllTrails https://www.alltrails.com/pl-pl/ar/szlak/finland/northern-savonia/puijon-polku, [dostęp:10.08.2024, 20:35].

[7] Eero Antikainen, 2022, Savonia University of Applied Sciences.

ARCADIS

MANHATTAN New York

Population: About 8.3 million people
(including 1.63 million in Manhattan).
Area: 783.8 square kilometres.
Population density: 10,712b per square kilometre.

One of the largest cities in the world, New York faces serious challenges related to climate change. Rising sea levels, more frequent and intense storms, and increasingly severe heat waves pose a threat to the city's infrastructure and its residents, especially those living in coastal areas such as lower Manhattan.

Throughout its history, New York has experienced several significant floods which have had a lasting impact on the city's development and infrastructure. One of the first documented floods took place in 1821, when a powerful hurricane caused a sharp rise in water levels, thus flooding lower Manhattan. In the 20th century, in 1938, the city saw the so-called "Long Island Express Hurricane", which caused serious damage on the East Coast.

However, the biggest shock for New York was the flooding caused by Hurricane Sandy in 2012. Storm surges flooded large parts of the city, including Manhattan's waterfront and subway systems, causing billions of dollars in damage. Sandy became a turning point in the perception of climate threats, thus forcing city officials to take sweeping actions such as strengthening flood defences and revising urban plans to better prepare for future disasters.

EAST SIDE COASTAL RESILIENCY (ESCR)

Solution Description

The East Side Coastal Resiliency (ESCR) project is a comprehensive initiative to ensure protection of Manhattan's East Side residents from flooding caused by climate change and sea level rise. The project covers 2.4 miles of waterfront along the East

River, from Montgomery Street on the Lower East Side to East 25th Street in the Kips Bay neighborhood. ESCR includes a range of integrated flood protection measures, such as flood walls, embankments, and flood gates. These solutions are supported by park areas, modernized drainage infrastructure, and amenities for residents which not only protect but also revitalise the waterfront. In accordance with its design, the ESCR system combines sound engineering solutions with the community's needs for green space and waterfront access, ensuring long-term resilience to the effects of climate change and improved quality of life for residents..

Figure 1 Visualization of the ESCR project; source: nycgovparks.org

Project Background and Context

The ESCR project was created following Hurricane Sandy in 2012. What the phenomenon brought to light was high vulnerability of New York to extreme weather events and rising sea levels. The eastern part of Manhattan, characterised by a mix of residential, commercial, and recreational spaces, suffered significant damage during the hurricane. In the aftermath of the disaster a decision was made to provide federal funds through the Department of Housing and Urban Development (HUD) to the Rebuild by Design competition. The competition aimed at creating innovative solutions strengthening coastal defence and at the same time improving the quality of life of residents and environmental protection. The ESCR project was the best proposal. It was developed along with public participants, through extensive public consultations and cooperation between city agencies, environmental organizations, and residents. What makes the project worth looking at is not only its scale and ambition, but also integrating community feedback into design and implementation phases.

Importance for Climate Change

The ESCR project is a key response to the growing threats posed by climate change, especially for urban coastal communities. As global temperatures rise, so do sea levels and the frequency and intensity of storms, which in turn increases the risk of flooding and storm surges in coastal cities. ESCR addresses the problem by making cities more resilient, combining infrastructure designed to withstand extreme weather events with sustainable environmental solutions. The project has its notable influence on social exclusion as it covers some of the city's most vulnerable neighbourhoods, many of which are low-income and historically underinvested areas. By integrating adaptive, natural solutions with engineered structures, not only does ESCR minimise immediate threats, but also provides direction for how cities can proactively counter the effects of climate change.

Figure 2 Future view from the Houston Street entrance to East River Park; source: nycgovparks.org

Possibilities of Implementation in Other Places

The ESCR model offers guidance for those cities around the world which face climate challenges. The proposed approach to managing climate crises in connection with community engagement and environmental care allows for adaptation to other coastal urban areas looking to increase their resilience. Key elements of ESCR, such as a combination of hard infrastructure (e.g. flood gates) and soft infrastructure (e.g. parks), can be adapted to local conditions, e.g. different types of coastlines, hydrological conditions, and needs of residents. Additionally, an emphasis on inclusive planning processes and collaboration between the public and private sectors provides a framework for building local support and obtaining the necessary funding to implement such solutions. While each city's resilience strategy must be specific and tailored to local conditions, the ESCR underlying principles allow for implementation of many solutions in other cities - robust and adaptive design, citizen-focused planning, multi-functional infrastructure - offer a model for many cities looking to protect themselves from the growing impacts of climate change.

ROMAN ZHEBCHUK

[https://en.wikipedia.org/wiki/Green_Bay,_Wisconsin]

GREEN BAY USA

Population: 107,395
Surface area: 144.42 km²
Population density: 887.79/km²

[https://images.app.goo.gl/XfakFrDrMfh42gcV6]

ABOUT CITY

Green Bay is a city in and the county seat of Brown County, Wisconsin, United States. It is located at the head of Green Bay (known locally as “the bay of Green Bay”), a sub-basin of Lake Michigan at the mouth of the Fox River. As of the 2020 census, the city had a population of 107,395, making it the third-most populous city in Wisconsin, after Milwaukee and Madison, and the third-most populous city on Lake

Michigan, after Chicago and Milwaukee. *[https://en.wikipedia.org/wiki/Green_Bay,_Wisconsin date & time 24.09.24, 16:00]*
Green Bay founded in 1634 by French explorer Jean Nicolet, the city initially served as a fur trading post between the French and Native American tribes, particularly the Menominee and Ho-Chunk. Over time, Green Bay evolved into an important port and industrial hub, particularly benefiting from the lumber industry during the 19th century. Its location along the Fox River and proximity to Lake Michigan played a vital role in its economic development, making it a strategic location for shipping, agriculture, and industry. Today, Green Bay is best known for its passionate sports culture, especially the NFL's Green Bay Packers, but the city also excels in environmental leadership.

CASE STUDY

Green Bay has developed an effective model for water management that balances urban development with environmental protection. The city's strategies are notable for their focus on stormwater management, watershed protection, and collaboration with diverse stakeholders, including agricultural communities, conservationists, and local governments. These efforts make Green Bay a good case study in sustainable water management, especially relevant for cities facing similar environmental challenges.

I. Stormwater Management through Green Infrastructure

Green Bay's approach to stormwater management centers on **Green Stormwater Infrastructure (GSI)**, which uses natural systems to manage runoff and reduce flooding. Key components of GSI in the city include *[Green Stormwater Infrastructure Initiatives. https://greenbaywi.gov/1300/Green-Stormwater-Infrastructure-Initiati, date: 24.09.24, 17:00]*:

- Planned Natural Landscapes: The City and Sustainability Commission finds it is in the public's interests to encourage diverse landscape treatments throughout the City, particularly those landscape elements that support the preservation, restoration, and management of native plant communities, healthy pollinator communities, and soil and water conservation.
- Residential Rain Barrel Program: The Residential Rain Barrel Program offers City of Green Bay residents a chance to receive a FREE rain barrel. There is a limited supply of rain barrels, so residents will be randomly selected to receive one once the registration period is over.
- Residential Green Stormwater Infrastructure Revolving Loan Fund: The Green Stormwater Revolving Loan Fund will provide low-interest loans to residential property owners to install green stormwater infrastructure (GSI) on their property. GSI helps soak up stormwater runoff close to where the rain and snow falls.

These GSI solutions are designed to mitigate the urban heat island effect, improve air quality, and enhance the city's resilience to flooding. Additionally, Green Bay's residential rain barrel programs encourage citizens to collect and reuse rainwa-

ter, which further reduces runoff and water consumption *[Stormwater Management Plans, https://greenbaywi.gov/1460/Stormwater-Management-Plans, date: 24.09.24, 16:00].*

II. New Watershed Program and Adaptive Management

The **NEW Watershed Program (NWP)** is a landmark initiative aimed at improving water quality in Green Bay and the surrounding areas, particularly the Fox River and the Bay of Green Bay. The region faces significant environmental challenges, with phosphorus and sediment runoff contributing to poor water quality and algae blooms. The program addresses these issues through an **adaptive management** approach, which emphasizes flexibility and collaboration between various stakeholders to achieve long-term improvements.

Key components of the program include:

Collaboration with Farmers: Agriculture is a major contributor to runoff, particularly from phosphorus and other nutrients used in fertilizers. The NWP works directly with farmers to implement conservation practices that reduce nutrient and sediment runoff, such as buffer strips, cover crops, and no-till farming. This cooperation not only helps improve water quality but also maintains agricultural productivity.

Pilot Projects: The program builds on successful pilot initiatives, such as the Silver Creek Pilot Project, which began in 2014. This project demonstrated the effectiveness of collaborative conservation efforts over 4,000 acres of agricultural land. The success of Silver Creek has led to the scaling up of the initiative, with the new program covering approximately 40,000 acres in the Ashwaubenon Creek and Dutchman Creek watersheds *[NEW Watershed Program: Ashwaubenon Creek and Dutchman Creek, https://www.newwater.us/programs/watershed, date: 24.09.24, 16:00]*

Public and Private Partnerships: The program's success is also due to partnerships with local governments, conservation groups, universities, and private entities. These partnerships provide funding, expertise, and manpower for long-term water quality monitoring and improvement efforts. The collaborative nature of the initiative allows for adaptive solutions that can respond to changing environmental conditions and regulatory requirements. *[Pollution prevention initiatives, https://www.newwater.us/programs/pollution-prevention-initiatives, date: 24.09.24, 16:00].*

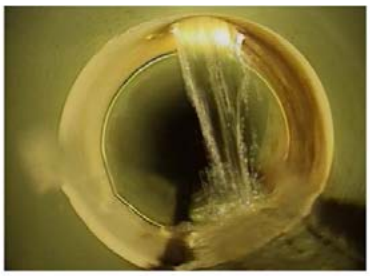
III. IT and BigData usage in Water Management

1. IoT usage in Water Management

Green Bay has embraced the use of IoT (Internet of Things) technologies in its water management strategies to optimize resource usage and enhance the efficiency of its infrastructure. These technologies are increasingly being integrated into both the city's stormwater management and broader environmental monitoring initiatives.

Green Bay uses **smart sensors** in its stormwater system to monitor real-time conditions in its drainage and sewer systems. These sensors provide data on water flow, levels, and potential blockages, allowing city officials to manage stormwater more effectively, especially during heavy rainfalls. By having real-time data, the city can prevent flooding by adjusting infrastructure responses, such as rerouting water or managing the release from retention ponds.

Picture above: Root intrusion into a pipe indicates likely infiltration of clear water and can block sewer flow, NEW Water Televising Program.



Picture above: Likely illicit sump pump connection discharging inflow of clear water into the sanitary sewer, NEW Water Televising Program 9/6/2018.

[https://www.newwater.us/projects/inflow-infiltration]

For instance, **smart water meters** and remote sensors monitor flow levels in critical areas to prevent overflow and ensure efficient water usage. This real-time data helps engineers and planners better manage the infrastructure, adjusting in advance to potential risks such as storm surges or high water levels. This dynamic control enables a more adaptive response to extreme weather, reducing the likelihood of flooding and minimizing the impact of urban runoff. *[https://www.newwater.us/projects/inflow-infiltration]*

2. Watershed Monitoring and Data Collection

In addition to stormwater systems, Green Bay uses IoT devices in its watershed management efforts, such as the **NEW Watershed Program**. The IoT sensors deployed in key areas of the watershed continuously collect environmental data, such as water quality metrics (phosphorus levels, turbidity, etc.), helping in the long-term management of water bodies like the Fox River and Green Bay. This data allows stakeholders, including farmers and environmental managers, to monitor water conditions in real time and make data-driven decisions that prevent harmful runoff into the watershed [Aquatic Monitoring Program, https://www.newwater.us/programs/aquatic-monitoring, date: 24.09.24, 17:00].

3. Improving Efficiency with Data Analytics

IoT systems in Green Bay are often combined with **big data analytics** and cloud-based platforms (https://www.newwater.us/programs/aquatic-monitoring/water-data), enabling the city to predict trends in water management and maintenance needs. By analyzing historical data alongside real-time sensor information, the city can prioritize areas needing infrastructure upgrades, thereby improving overall efficiency and reducing costs associated with emergency responses to flooding or water contamination events.

IV. Branding strategy

Green Bay uses special “New Water” brand for water facilities and marketing strategy, that highlights its innovative and sustainable approach to water management.

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

SPECIAL FEATURES OF THE STRATEGY:

1. Brand Positioning as a Leader in Sustainability

NEW Water promotes itself as more than just a utility—it brands itself as an environmental steward with a mission of "Protecting our most valuable resource: water". By positioning itself as a forward-thinking leader in sustainability, NEW Water appeals to environmentally conscious citizens, businesses, and policymakers. This aligns with broader societal trends of supporting green initiatives, enhancing community buy-in and trust.

2. Resource Recovery Narrative

A standout feature of the NEW Water brand is its focus on resource recovery. It reframes wastewater treatment from being a process that only deals with waste to one that recovers valuable resources like clean water, energy, and nutrients. This makes the brand's story more dynamic and innovative, aligning it with circular economy principles, which resonate with environmentally conscious markets.

3. Community Engagement and Public Education

NEW Water actively involves the community in its water management journey through outreach programs, tours, and educational initiatives. By focusing on public education, such as teaching about pollution prevention, the brand strengthens its role as a community partner. This enhances its reputation, showing that it cares about empowering people with knowledge, not just providing a service.

4. Highlighting Local Projects

Through initiatives like the Silver Creek Project, NEW Water shows its commitment to improving water quality through practical, on-the-ground actions. It highlights these efforts in its marketing, showcasing how it's helping to reduce nutrient runoff from farms, a key issue in Green Bay. By focusing on local projects, NEW Water ties its brand directly to the wellbeing of the region, making its efforts more tangible and relatable for local residents.

5. Transparency and Accountability

Through consistent public reporting on water quality, pollution levels, and project outcomes, NEW Water maintains transparency. This openness builds trust and assures the public that the utility is accountable for delivering real, measurable benefits.

OUTCOMES

Green Bay's innovative approach to water management demonstrates how cities can address complex environmental challenges through sustainable practices, collaborative partnerships, and adaptive strategies. By focusing on green infrastructure and working with agricultural and community stakeholders, the city has been able to significantly improve water quality while maintaining its economic and agricultural vitality.

Green Bay's water management efforts could be used in polish communities for:

- **Improving Water Quality**: The NEW Watershed Program has already shown improvements in water quality in its pilot areas, with reduced phosphorus levels and sediment loads in key watersheds. These improvements help protect the Fox River and Bay of Green Bay, both of which are critical to the region's economy and ecology.
- **Cost-Effective Solutions**: By focusing on natural and agricultural solutions to water management, Green Bay's approach is more cost-effective than traditional grey infrastructure solutions (such as large water treatment facilities). This reduces the financial burden on the city while achieving better long-term environmental results.
- **Replicable Model**: Green Bay's success provides a replicable model for other cities dealing with similar water management challenges. The combination of green infrastructure, adaptive management, and strong public-private partnerships offers a sustainable and flexible framework that can be adapted to different regions and environmental conditions.
- **Making data-driving decisions in community management.** IT and BigData usage in Water Management enable real-time monitoring, proactive responses, and data-driven decision-making, which together help the city optimize water use and improve environmental outcomes.

Green Bay's success offers valuable lessons for other urban areas looking to enhance their water management systems and environmental sustainability.

ANDRZEJ TIUKAŁO, SZYMON MARCZAK

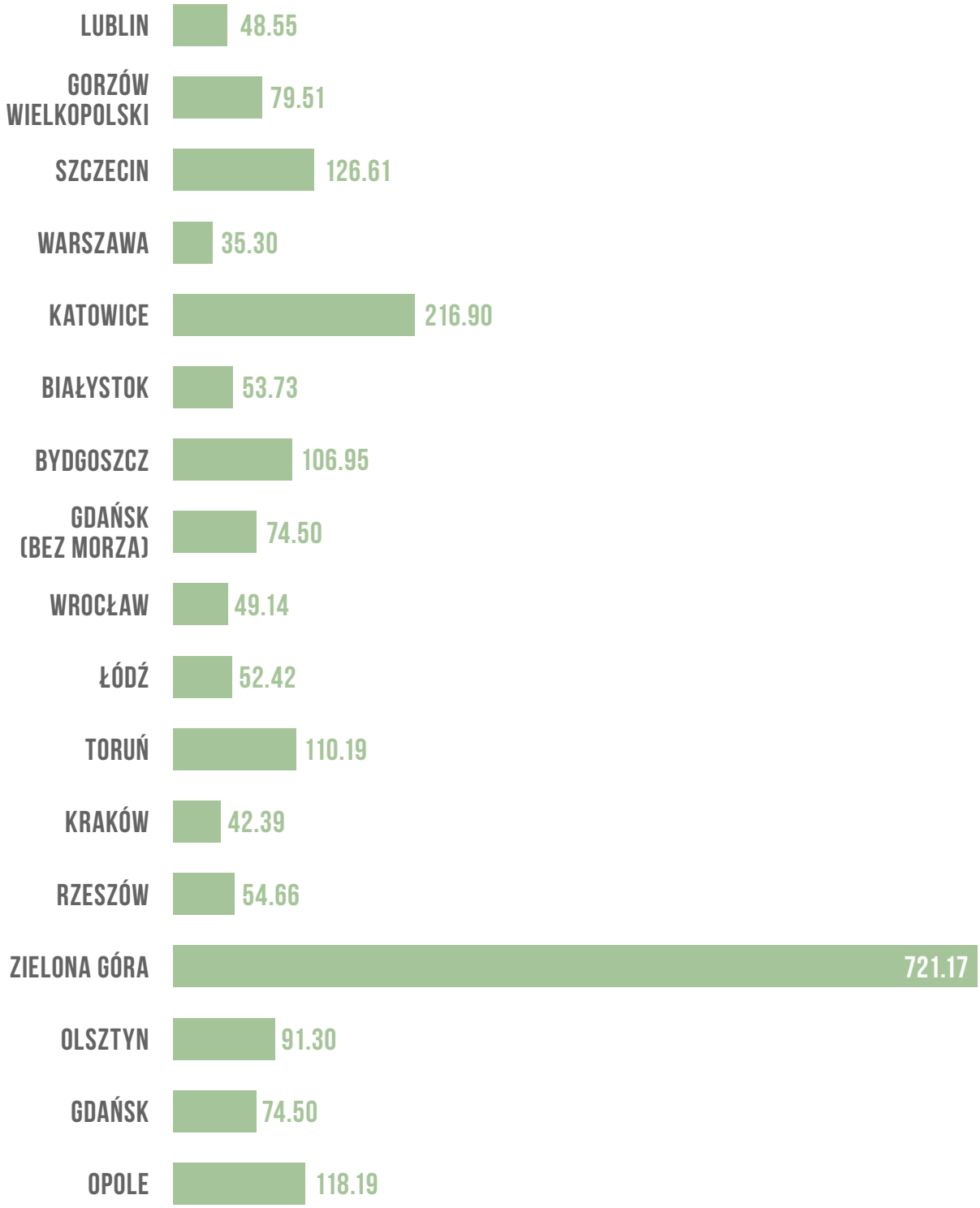
WATER FOOTPRINT OF CITIES

The city's water footprint is a multidimensional indicator of the city's annual water consumption, conventionally called green, blue, and grey water. ***Green water footprint*** refers to the part of the annual volume of rainwater which evaporated from the soil surface (evaporation) and the surface covered with vegetation (transpiration), as well as the water which was used by vegetation located in the city. ***Blue water footprint*** is the annual consumption of surface or underground water for the needs of residents and other needs related to the functioning of the city and part of the annual volume of rainwater evaporating from sealed surfaces. Finally, ***gray water trace*** is the annual volume of clean water necessary to dilute the pollutant loads discharged by cities into the receiving body to the extent that the water quality in the receiving body does not exceed applicable water quality standards. Thus, the water footprint offers a perspective allowing for answering the question: ***How does a city address the use of available freshwater systems?***

As part of the analysis of the water footprint of provincial cities in Poland presented at the Conference, the values of all water footprint components were determined for each city and, on this basis, there were identified cities which stand out in terms of their blue and grey water footprint values per capita.

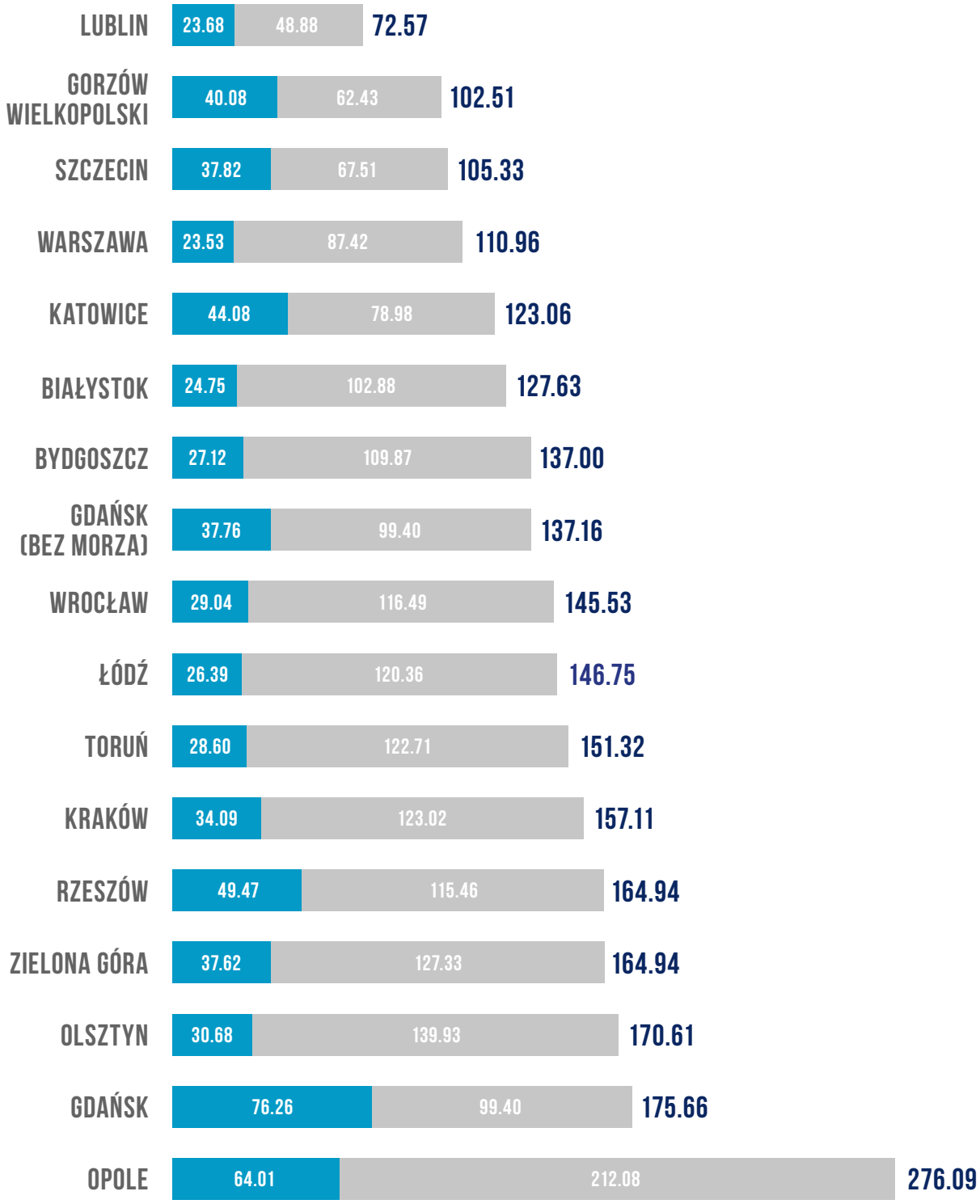
Assessment of a city's water footprint involves analysing the impact of the city's activities on water scarcity and water pollution. Such assessment allows for rational and sustainable actions to be taken with a view to improving the identified condition in this area while improving quality of life of residents. These activities can be planned using comprehensive analyses of the city's green, blue, and grey water footprint and their spatial distribution.

GREEN WATER FOOTPRINT OF CITIES PER INHABITANT (m³)



THE RANKING RESULTS (m³)

(BLUE WATER FOOTPRINT PER INHABITANT + GRAY WATER FOOTPRINT PER INHABITANT)



THE RANKING RESULTS

WATER CITY INDEX 2024

THE RANKING RESULTS 2024

METROPOLISES

I PLACE
WROCŁAW

II PLACE
ŁÓDŹ

III PLACE
BYDGOSZCZ

CITIES WITH POVIAT RIGHTS

I PLACE
SŁUPSK

II PLACE
GDYNIA

III PLACE
GORZÓW WIELKOPOLSKI

MEDIUM-SIZED CITIES

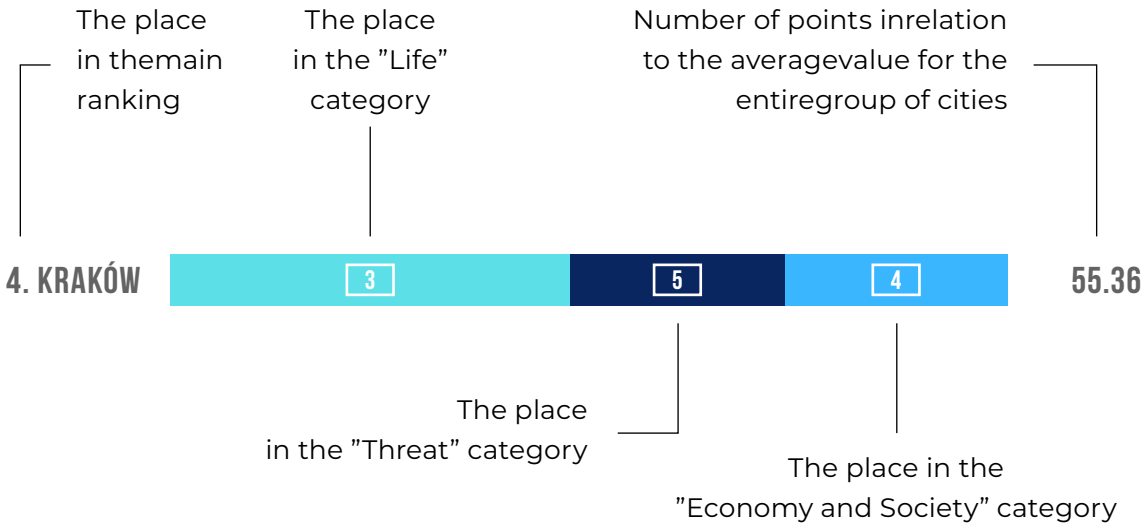
I PLACE
MRĄGOWO

II PLACE
AUGUSTÓW

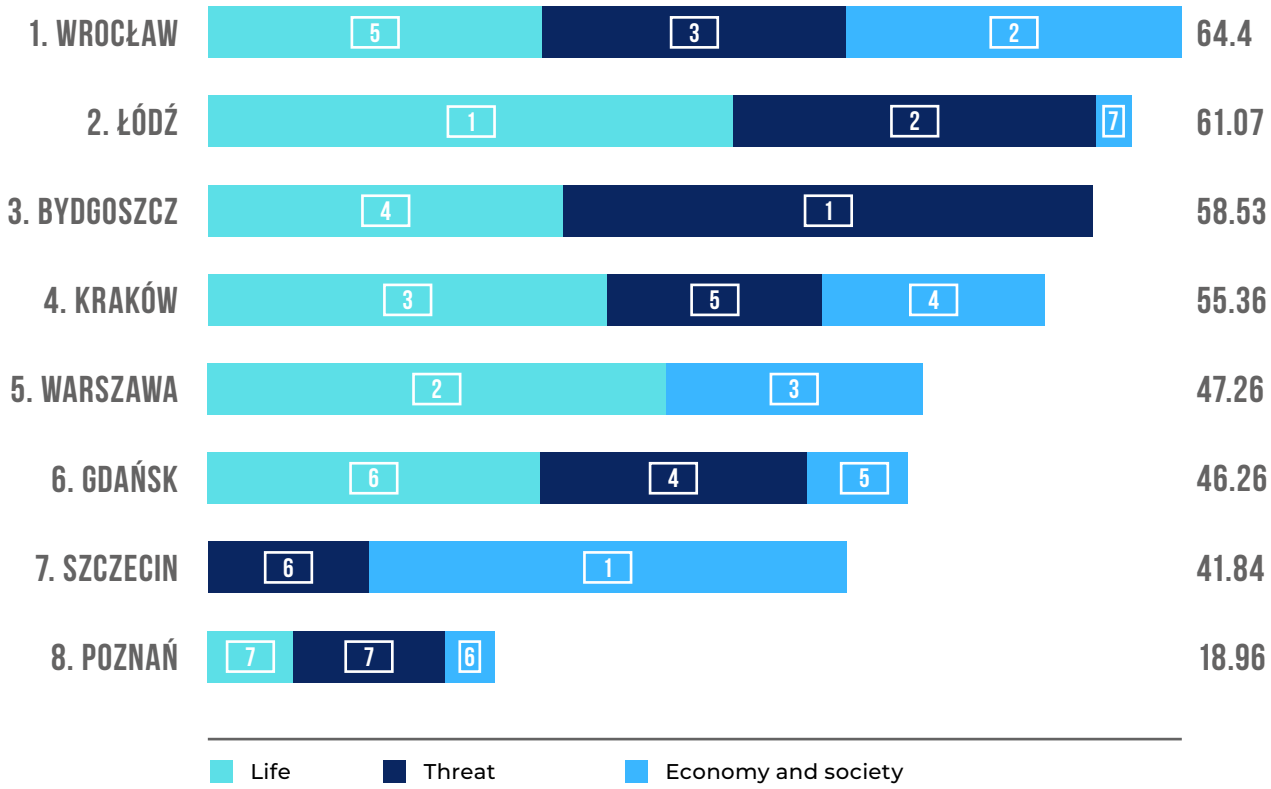
III PLACE
ŻYWIEC

INTERPRETATION OF THE RANKING

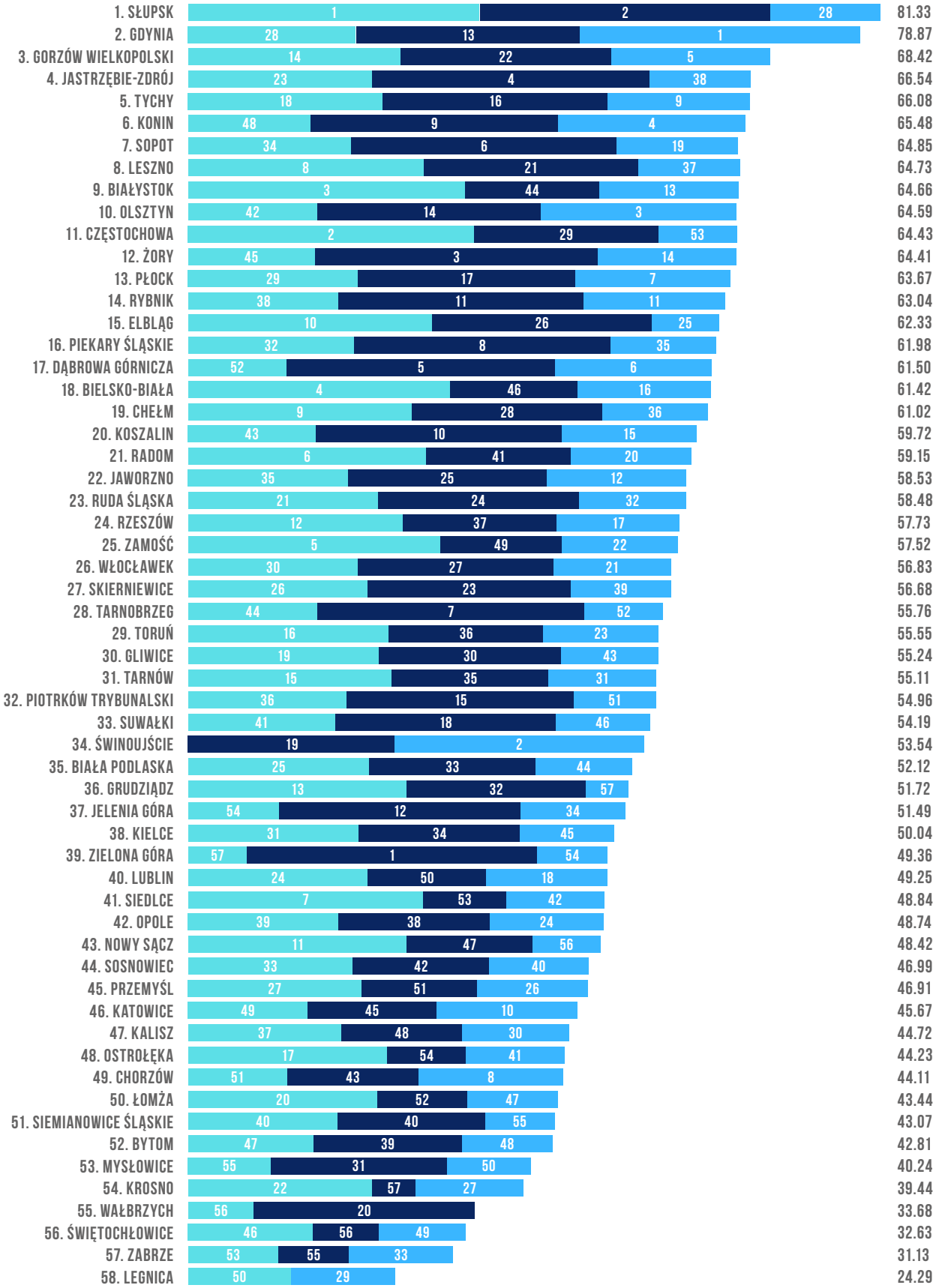
For metropolises and cities with poviat status , the main ranking lists the results of the rankings inindividual categories: The results are presented in the form of numbers indicating the position of agiven city in each category, shown on the corresponding bar of the graph.
In the case of the charts prepared for the ranking of metropolises and the ranking of cities withpoviat rights, the width of individual blocks in the chart reflects the share of a given category in theoverall rating of the city, and since different weights were used for the three categories in the finalrating, the width of these blocks is not always comparable between cities.



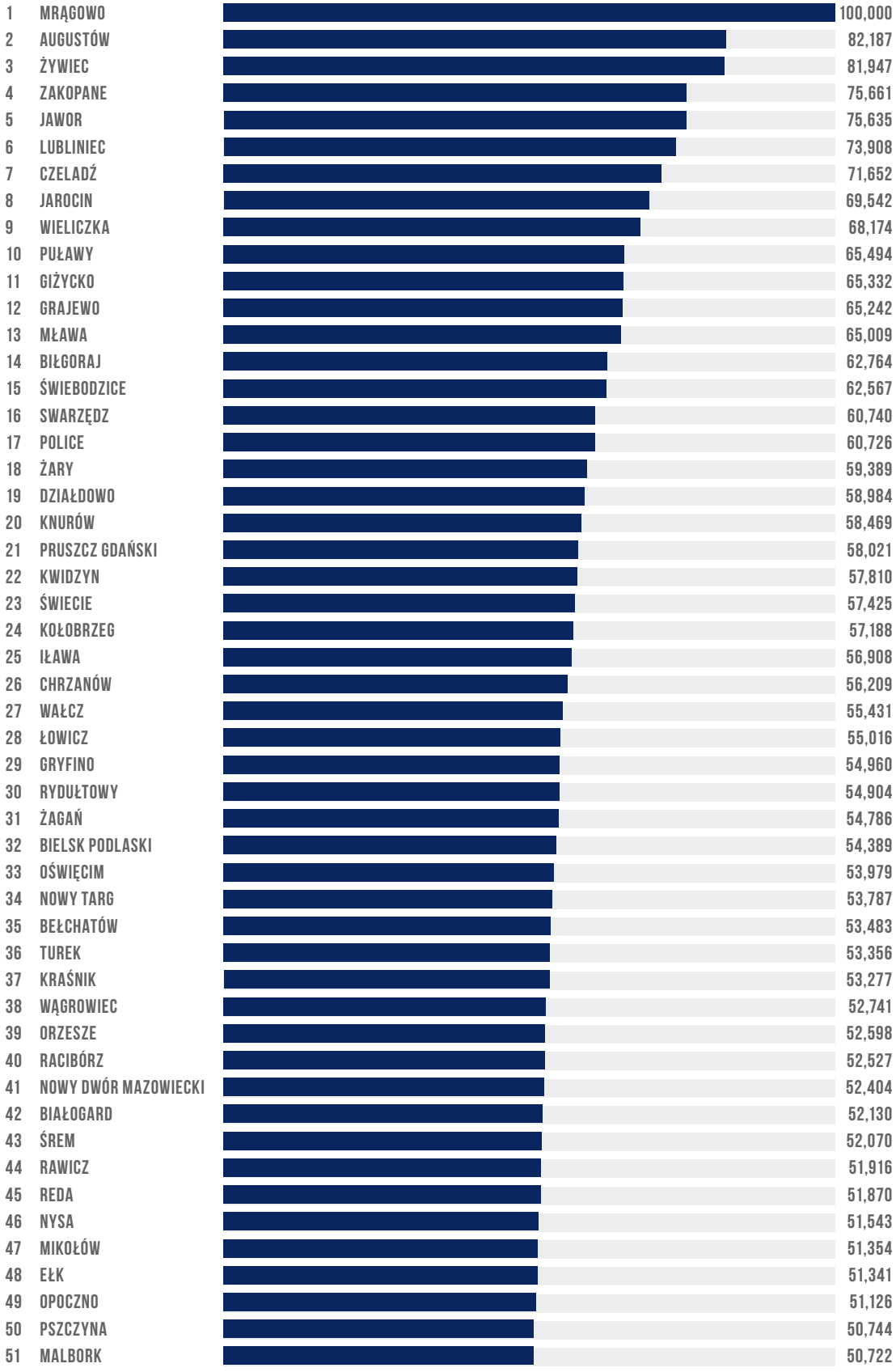
THE 2024 WCI RESULTS – METROPOLISES



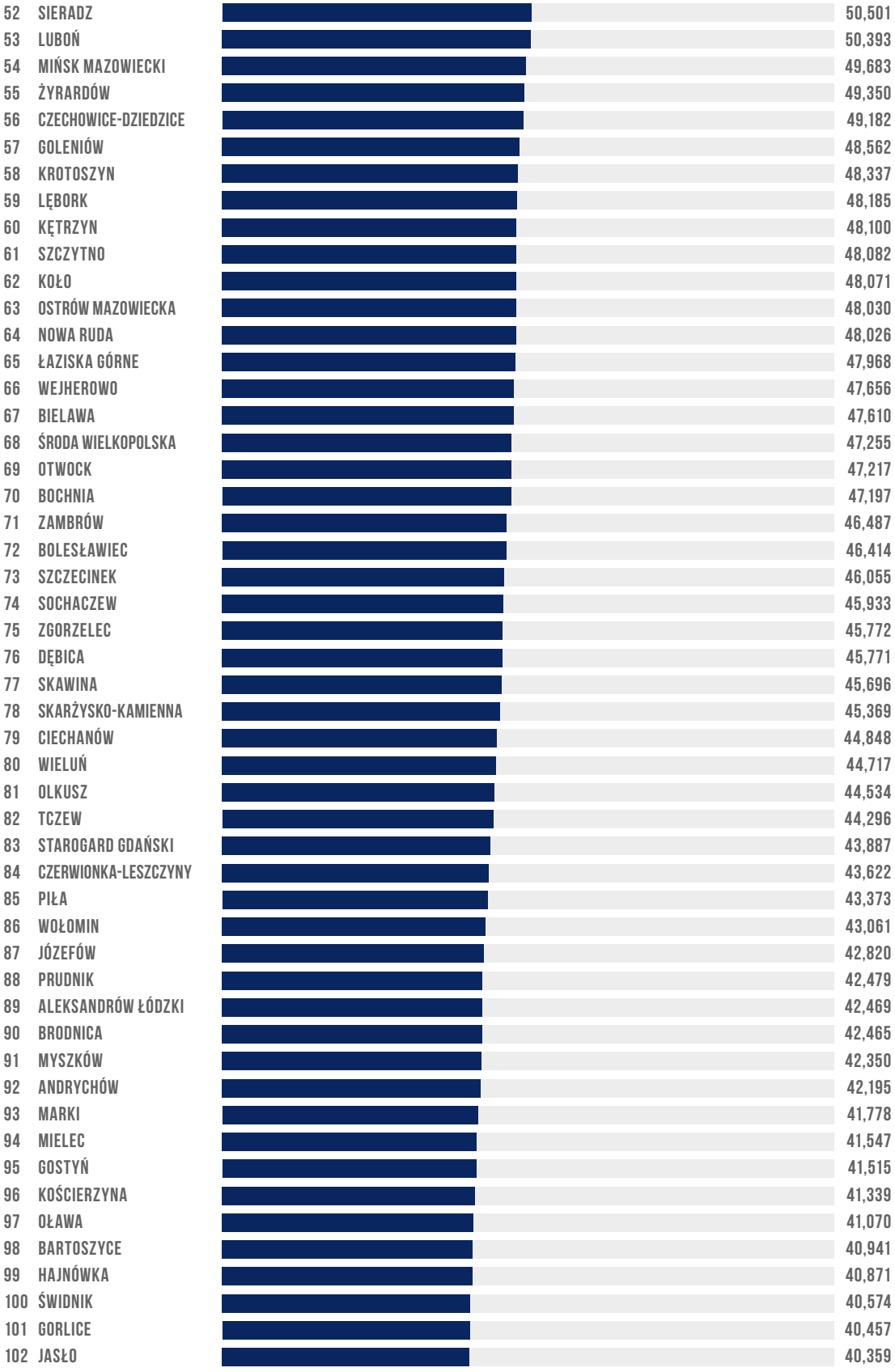
THE 2024 WCI RESULTS – CITIES WITH POVIAT RIGHTS



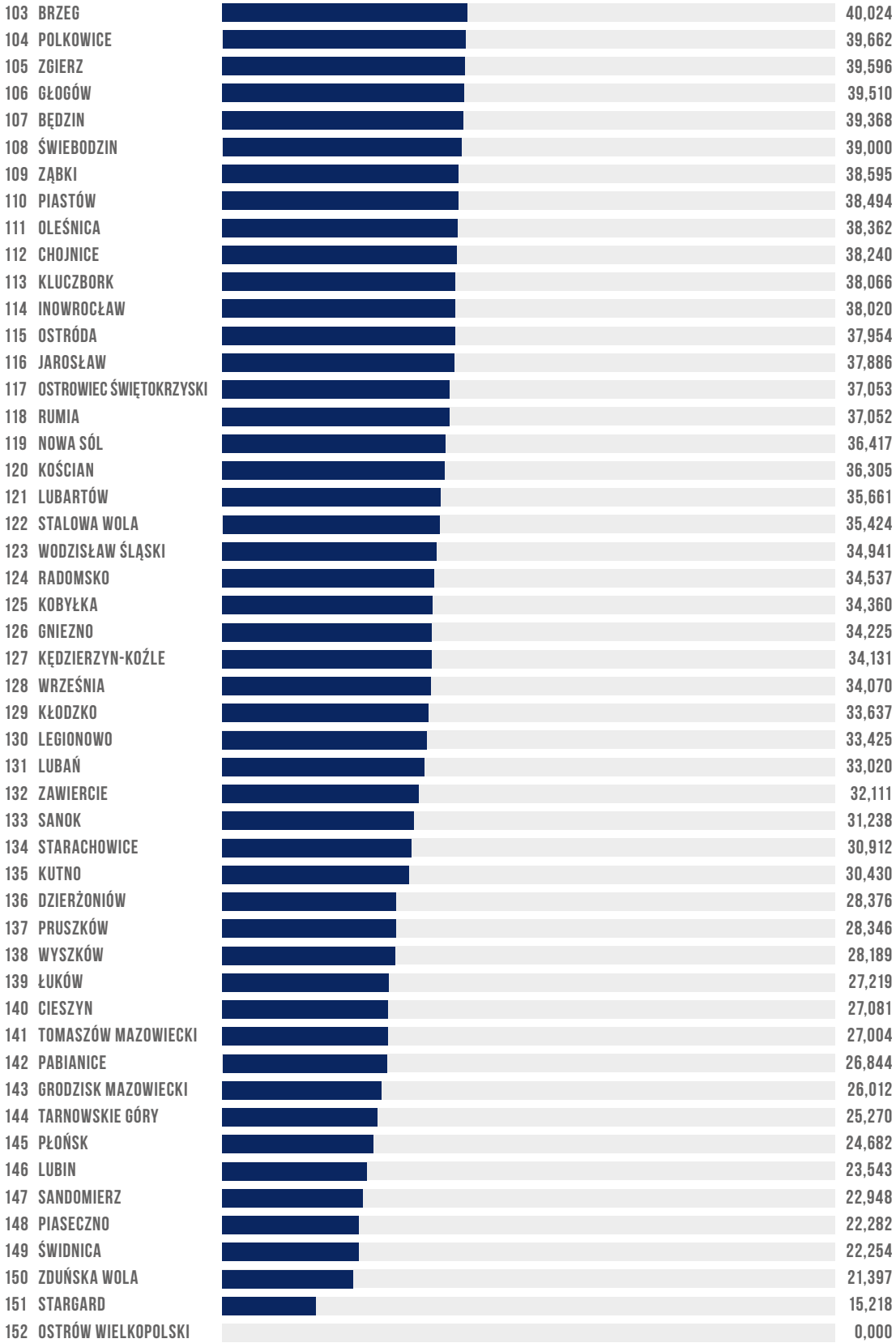
THE 2024 WCI – MEDIUM-SIZED CITIES



THE 2024 WCI – MEDIUM-SIZED CITIES



THE 2024 WCI – MEDIUM-SIZED CITIES



SUMMARY OF THE 2024 WATER CITY INDEX (HOW WE INTERPRET THE RESULTS...)

What makes modern times stand out is rapid climate changes along with their consequences. This is particularly visible in two areas: agriculture and highly transformed urban spaces. Therefore, particular emphasis should be placed on the growing importance of urban water policies, also in Poland. With regard to the functioning and development of cities, it is virtually every area that shows consequences for water relations. For example, the urban spatial policy should assume harmony, functionality, and sustainable nature of space. Therefore, urban waters should be treated consciously and responsibly, with a focus on their effective use.

Cities are likely to suffer from two types of water crises: alternating droughts and floods of different types and severity scales. The number of consecutive days on which the air temperature will exceed 33 degrees Celsius with a simultaneous lack of precipitation will increase. Therefore, in the WCI, while assessing urban water policies, we are looking closely at the degree of preparation of urban infrastructure for such situations. The question is not “if?”, but “when?”, “how much?”, and “how thoroughly are we going to be prepared for the upcoming crisis?” The 2024 Water City Index was developed in the year when Poland experienced a water shortage crisis, recording the lowest level of the Vistula river in the history of measurements, and immediately afterwards, thus becoming a victim of a catastrophic flood. Poland, and particularly the Kłodzko Valley, experienced disastrous violent weather events in September 2024. These events have forced us to think about water crises and how to mitigate them in a decisive, systemic, and integrated manner. We need structured actions executed by public administration at the central level, as well as medium- and long-term solutions both in the infrastructural and educational areas at the local level.

Water is a multifunctional resource – we emphasised this fact also in the previous Water City Index rankings. Hence the broad perspective of looking at this resource, but also the specific way of dividing water resources for the needs of analyses and as-

sessments adopted in the 2024 WCI. The cities which won our ranking were those that implement urban and water policy in a sustainable way, looking at water resources broadly and responsibly.

This year's edition of the ranking, similarly to the previous one, focuses on three key areas: **Life**, **Threat**, and **Economy and society**, thus allowing for multidimensional assessment of cities in the context of their approach to water resources. We have also continued the division of the ranking into three groups of cities: metropolises, cities with poviat rights, and medium-sized cities. The aim of the ranking is not to award laurels to cities, but to provide objective data supporting more conscious and strategic water management in the city.

LIFE – the first of the analysed areas - refers to the everyday use of water resources by residents, and takes into account, among others, water and sewage management, network failure rates, water consumption, as well as water availability and price per cubic metre. The highest ranks in this category are taken by these cities which successfully minimize water losses and ensure equal access to water resources, while taking care of the infrastructure which ensures comfort and safety for residents.

THREAT is another critical aspect included in the ranking which focuses on resilience of cities to water crises such as droughts, floods, and extreme weather events. Here, protection of green and blue-green infrastructure is an important element, which not only helps to prevent formation of urban heat islands or to improve air quality, but also plays a key role in rainwater retention and counteracting the phenomenon of surface sealing (excessive use of concrete). Cities, which effectively protect their water resources invest in retention infrastructure and take care of biodiversity, are more resistant to climate change and its effects.

ECONOMY AND SOCIETY is the last of the three key areas. The assessment focuses on how cities use water resources in order to strengthen their economic competitiveness and improve quality of life of their residents. In this category, skillful development of riverside areas also plays a key role, as it not only attracts tourists and investors, but also promotes local recreation. Through development of water resources in a sustainable and multi-functional manner, cities ensure benefits for both the economy and inhabitants, while protecting resources for future generations.
In this year's metropolis ranking, it was Wrocław to take the first place, ahead of Warsaw and Kraków. Wrocław stands out for its water resources management policy, investments in retention infrastructure, and modern solutions within the field of water environment protection. In the category of cities with poviat county rights, the first slot was taken by Słupsk, which overtook Gdynia and Gorzów Wielkopolski thanks to the effective use of water resources and resistance to environmental crises. In turn, in the category of medium-sized cities, Mrągowo came first, only to be followed by Augustów and Żywiec.

In the 2024 Water City Index, the winning cities stood out from others thanks to their comprehensive approach to water resources management, effectiveness in responding to threats, and implementing sustainable solutions. Wrocław was ranked first in

the metropolis category, chiefly as a result of its advanced infrastructure counteracting the effects of water crises and innovative projects aimed at minimizing water loss and improving water quality. Wrocław successfully combines urban development with protection of green areas and care for the local ecosystem. The leader in the category of cities with poviat rights, Słupsk is distinguished primarily by its proactive drought prevention policy and effective use of available water resources in strengthening the local economy. Mrągowo, which has triumphed in the category of medium-sized cities, invested in the infrastructure supporting water recreation and boasts a sustainable water policy across all areas of analysis, which in turn improved quality of life of residents and increased tourist attractiveness. Each of these cities has shown that through strategic water management we are able to solve current problems, but also build long-term resilience to future climate challenges.

The 2024 WCI is not a classic ranking based on subjective assessments or a “beauty pageant”, but an objective tool for analysing the standing of cities in terms of sustainable water management. The ranking provides data and tips which may be used by local governments in order to better understand the challenges and to them to take actions aimed at improving the situation.

The cities with lower ranking results are not doomed to failure - the ranking is an introduction to an in-depth analysis of individual needs and opportunities. Each city has a unique character, and the water challenges faced thereby may vary depending on local conditions. The ranking can therefore be a valuable tool which points to the areas requiring improvement and identifies strengths that can be further developed.

As the threats related to water crises and climate change are on the rise, effective management of water resources is becoming crucial for the future of cities. Freshwater is an exhaustible resource, and its improper use may lead to environmental degradation and a decline in the quality of life of residents. Only through a conscious and sustainable approach, consistent with the assumptions of the circular economy, will cities be able to mitigate the effects of climate change and secure the future of their inhabitants. The 2024 Water City Index emphasises the need for multifunctional use of water resources - not only for economic purposes, but also for social and ecological ones. Cities which understand this need will not only be more resilient to future challenges, but are also likely to become role models for others in sustainable development.

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