D 4.1 Report on SMART visions in demo sites

Kinga Krauze, Kati Vierikko, Antti Rehunen, Pascal Breil, Renata Włodarczyk-Marciniak, Iwona Wagner

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1. Introduction

Upscaling of nature-based solutions (NBS) in cities requires a general agreement of the players on the direction in which city should develop. By one of early definitions NBS are actions which "are inspired by, supported by or copied from nature" (EC, 2015), and "have tremendous potential to be energy and resource-efficient and resilient to change, but to be successful they must be adapted to local conditions". The current approaches emphasize that NBS are "to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature" (IUCN, 2022, https://www.iucn.org/our-work/nature-based-solutions). As such NBS require reference sites / conditions as a source of biodiversity and processes encompassed as ecosystem services, transfer zones along the natural capital gradients and enabling city conditions being namely: water supply, land provision, time allowance (as natural systems usually reach stable state after years) and in fact societal consensus over all of those, plus readiness to bear the consequences such as some implementation costs, lost opportunity costs, or living with uncertainty.

Thus it is essential to base NBS upscaling on co-development of a vision – shared overview of a desirable state to be achieved in the future, joint analysis of path(s) towards achieving this state, what requires scenario analysis, and finally defining a strategy as a set of activities aimed at achieving the vision.

To be productive vision must be SMART: SPECIFIC, MEASURABLE (MODEL-ABLE), ACCEPTABLE, REALISTIC, TIMEBOUND. Specificity means that the vision precisely describes the desirable state, not leaving space for misunderstanding, especially that it sets the target for many years ahead and therefore often for different generations. Being measurable allows control over substargets, elements and therefore marking the progress. This feature is translated into strategy with all the implementation indicators. Acceptability means that all the stakeholders understood the costs and benefits, agree on the "stake" and its importance and value, and decide for actions with all the consequences. As nature management in cities is a case of a wicked problem, it is very rare to achieve a state when all the stakeholders are fully satisfied, therefore it is critical that all of them feel listened, considered and happy enough to compromise. Realistic vision enables development of action plan and reaching milestones along an adopted time line, what allows vision to be time bound, and set the end point for actions.

The ATENAS cities took diverse ways of building the SMART visions. The City of Łódź has created the blue-green vision already in 2009 organising a series of meetings of the Learning Alliance group – a mutual learning, multi-stakeholder platforms. The vision was to be achieved in 2030, so in ATENAS checked where we are, what went wrong and how much we are on the track.
The sites of the Helsinki metropolitan area took – Kivisto and Vantaa – took a different approach. Learning from multi criteria decision analysis, pre-prepared by experts and consulted with local communities in a round of meetings, they establish a basis for water-friendly spatial planning.
The Lyon demonstration site developed and promoted NBS that require more specific knowledge and particular competencies. Therefore their further implementation does not require that broad and common societal agreement, however may happen only as a political decision of dedicated authorities and companies.

2. LYON: "Any drop of rain count"

In order to move forward with the adoption of NBS for stormwater management, it is necessary to have a clear picture of which departments have the authority to make decisions. In France, when it comes to stormwater management, the major urban metropolises are responsible for the governance of their territories in terms of infrastructure objectives and development. For the rest of France, this management is shared or delegated by communities of communes to syndicates that draw up diagnoses, and propose projects to adapt to the standards and regulatory documents arising from directives on water and wastewater for the most part. These actors are the key players in the game

of managing stormwater runoff in ways other than with pipes. To do this, we need to understand their problems.
In rural and peri-urban areas, the droughts of 2022 resulted in significant agricultural losses and damage to buildings nationwide. In France, agricultural losses are the cause of major tensions over the sharing of water resources. In urban systems, the issues of adapting to climate change are linked to the intensity of storm phenomena, which cause flooding and major damage to infrastructure, and to the heat island effect.
It is against this backdrop of droughts associated with scorching temperatures, water shortages and local, intense storms that those involved in rural and urban runoff management have set themselves the objective of "every drop of rain counts".

2.1 A lever based on climate urgency, trust and cost

In 2022, Lyon's rainfall deficit exceeded 52%, with 342mm of rain compared with an average of 741mm over the past 11 years. Severe thunderstorms with a multi-centennial return period hit the city in 2022 and 2023, when peri-urban rivers were dry. This is a semi-arid climate context, in which runoff resource management is absent. The warning shots fired by climate change and its direct consequences are strong arguments for reviewing runoff management as a whole. Awareness is marked by a desire to manage stormwater at source, for all interventions in the urban environment and all new construction in the peri-urban environment. This includes the management of rural areas that produce runoff, but also those that have the capacity to infiltrate it. The aim is no longer simply to protect against flooding, but also to manage this resource before it leaves through natural and artificial drainage networks. Last but not least, the cost of construction and maintenance must not be overlooked.

2.2 Obstacles to be overcome and methods for accelerating action

The rapid effects of climate change call for a complete overhaul of runoff management doctrine, and imply a political risk for decision-makers. Indeed, the lack of feedback on NBS is a source of uncertainty as to the right choice, particularly in the event of generalization. This is the point on which research is struggling most, given the paucity of follow-up data. What type of solution should be chosen, depending on the context? This is a weak point that is being legally attacked by real estate companies and homebuilders, who argue that the extra cost to their customers is not guaranteed. Scaling up therefore requires informed risk-taking, based on full-scale experimentation. To accelerate this process, the three components - decision-makers and managers, design offices and research - need to work together. Research works over the long term, validating results and methods of implementation, evaluation and control. Engineering firms build, and managers can provide the monitoring that feeds the research.

To sum up, the enabling factors / conditions for success are:

1. Confidence and knowledge of the level of risk taken by the decision-maker - manager: a no-regrets solution (with no consequences in the event of failure to achieve the set objective);
2. Verified regulatory and legal compatibility (no blocking complaint);
3. Controlled cost of the solution to limit unforeseen additional costs ;
4. Coordination between research/engineering office/decision-makers/managers to accelerate the process of diffusion.

2.3 Illustration of the smart approach for the demonstration site on a small peri-urban river in Lyon.

There are many storm overflow systems in the hilly western part of the Lyon urban area. This is the main cause of deterioration in river quality during heavy rainfall. This type of rainfall occurs in summer on streams with low runoff and no dilution capacity. The second cause of impact is linked to the modification of watercourses and their banks in a rapidly urbanizing area. This reduces the natural capacity for self-purification, which even on a natural level can vary according to geology, hydrogeology and topography. Stormwater overflows are a mixture of runoff and wastewater. Reducing runoff at source is not always possible in the short term. The network of peri-urban talwegs is therefore seen as the place to reduce pollution and encourage infiltration into the water table.

The demonstration site has been the subject of a preliminary scientific study on a small pilot river for around ten years. Numerous measurements were used to assess the effect of improving self-purification capacity to reduce the impact of a storm overflow. The long-standing partnership with local river and sewerage syndicates enabled the syndicates to validate the risk of replication on a watercourse 2.5 times larger (condition number 1). The cost of implementation was relatively low, as both banks of the river were owned by the river syndicate, which facilitated access to the area and provided a location that was not vulnerable to flooding. The syndicate covered the cost of materials and earthworks (condition number 3). Questions of appropriateness, legality and management were discussed with representatives of government departments (condition number 2). This type of watercourse accounts for the majority of the linear stretch affected. The design was carried out by a consultancy firm, under the supervision of the scientists and the river manager (condition number 4). This represents an initial transfer of knowledge and brings experience to the three components necessary for success: decision-makers / managers / design offices / scientists. Precise monitoring was carried out by the scientists. This validated the effectiveness of the solution based on amplifying the self-purification of a small river. It also enabled simple operating and early warning indicators to be transferred to managers. The operation was communicated to the public via information panels.

Replication of the project is planned for other rivers in the western Lyon catchment area, as well as at regional level via the regional association of river syndicates. The on-line presentation of the ATEANAS project is a guarantee of experience for the scientists who present the solutions tested, with their local, financial and legal constraints, and of a vision shared by the public who see their environment evolve.

3. ŁÓDŹ: “the city uses water wisely”

3.1 Method applied & visioning

In 2006 the City of Łódź entered the project SWITCH “Managing Water for the City of the Future” with a general aim to switch the way nature is perceived in cities and to pave the way for more sustainable use of natural resources including water and space. To develop vision inclusively, in the way embracing opinions of all the stakeholders, we lunched Learning Alliance (LA) – a multi-stakeholder platform, and an open forum of mutual learning through which a group of people sharing a problem and the desire to solve it, may develop common objectives and the required environment for mutual interaction between the stakeholders.
Two years of discussing of the most critical aspect to improve well-being in the future city led to organization of the visioning workshop in January 2008. The workshop brought together over 50 participants representing about 25 organizations and institutions, including both decision-makers and their ‘right hands’. Before the workshop, the higher decision-makers and executive levels in these organizations had not yet actively participated in the learning alliance. Realizing the seriousness of the workshop goals they seemed not to want to miss a chance to express their views and emphasize their commitment and involvement in the water management issues.

In the consequence LA formulated the vision by 2038 ‘Lodz Uses Its Water Wisely’ and:

‘(1) The city’s resources management is based on an efficient and integrated system ensuring access to information for all. (2) Investors and authorities respect ecological properties of land and waters. (3) Infrastructure serves the functions and requirements of an environmentally secure city, is reliable, meets the needs of all the city’s population and assures good status of aquatic ecosystems. (4) Green areas - river valleys along open corridors – provide space for recreation and are the ‘green lungs’ of Lodz. (5) The population’s common and in-depth ecological awareness contributes to exceptional quality of life. (6) Our city is a leading center for innovation, education and implementation in Poland.’

Subsequently the methodology has been adopted for a visioning process focusing on a wider issue than water management: the revitalization of the city as whole especially its historic and neglected ex-industrial zones.

3.2 Scenario building & mid-term evaluation of actions

In order to determine possible futures that may influence reaching the vision, LA developed scenarios as a consistent set of narratives helping to identify possible pathways (strategies) towards a shared vision of the future, based on current trends together with knowledge of the sources of greatest uncertainty in those trends.
In the first step LA identified all factors that would affect achieving the vision (local factors that may be open to change as well as external factors that are beyond direct control), and separated the local factors from the external ones. The stakeholders selected: i) city government policies in the areas of funds, demography, economic development rate and cooperation within city structures, ii) goodwill of decision makers, iii) climate and weather in the context of change, and iv) legislation. In the second step the factors were analysed against the uncertainty and importance, and two were indicated as critical to reach the vision: legislation and economic growth. From the time perspective both appeared to be significant and played both hampering and enabling role in realizing the vision.

In the third step the strategies leading to reaching the vision's components were listed as below. Considering that half of the time set for accomplishing the vision passed, it is possible to distinguish which actions has been undertaken - marked with green, are still under planning or discussion, hardly tackled, hampered on the way or being subject of self-sabotage[1] – with red, approached but in discontinued / ineffective way – with black.

1. **Integrated and efficient resource management system in and around the city of Lodz vicinity**: Centralized decisions, Lobbying for legislative improvements, Learning from the others, Covering 100% of the city area with local plans, Elimination of communication barriers between institutions, Creating a water resources database, Identification of leaders, Public consultations, promotion, consensus, Inclusion of marginalized groups.

2. **The infrastructure meets the functions and requirements of a safe city, is reliable, meets the needs of the inhabitants and ensures good ecological status**: Floodplains must remain undeveloped, Investments should meet ecological conditions in addition to economic ones, Raising investors' awareness, Unbundling of sewer systems, Decentralisation of rainwater management, Development of street greenery, Unsealing of surfaces, Stormwater monitoring, Use of proven technologies, Mass BMPs implementation - combination of technical and ecological methods - greater system efficiency at lower cost, Identification of illegal sources of pollution, Environmental monitoring system - establishment, extension, improvement.

3. **Green areas along uncovered river beds (river valleys, floodplains) for recreation - green lungs for Łódź:** Recognition of floodplain areas in the development plans, Restoration of selected sections of rivers, Increase of accessibility of recreational areas, Increase of PPP contribution to funding ecological investments, Better protection of informal greenery: either in local plans or by land purchase, Involvement of investors and developers in the restoration process (responsibility and finance).

4. **Good ecological status of waters in the city area:** Elimination of illegal waste discharges, Identification of risks to water bodies, Permanent monitoring, Improving the quality of rainwater discharged into rivers (separators), Separation of black and grey water, Inspection of private water bodies where economic activities are carried on, Implementation of vehicular traffic standards, Reduction of low emission, Broadening responsibilities of maintenance of nature to unusual suspects, e.g. ZDiT, Accomplishment of sewerage and wastewater treatment plant investments, Stopping urban sprawl, New technologies for decentralised

[1] Intentionally ignored or steps back done in order to strengthening position of some lobbying groups

wastewater treatment, Increasing water retention in catchment areas (landscape), Water reuse (reuse, harvesting), Unsealing, Increased funding for EH solutions.

5. **Łódź as a leading center for implementation, education and innovation in Poland:** Utilising the scientific experience of Łódź universities, Integration of the scientific community with investors, management and executive institutions, Development and use of new technologies developed in Łódź, Establishing of pilot LID estate, Development of DSS for integrated impact assessment, Promotion of Lodz as a city with an ecological image.

6. **High environmental awareness of the public:** Practical environmental education for children and young people using demo sites in the city, Showing children the waste treatment process, Building ecological village, Activation of districts boards and cooperatives, Awareness-raising media campaigns of the ECO CITY type, financed by the local government, Promotion - marches, rallies, Education - development of dedicated programmes for schools, Advertising nature - use of media, Establishing demo-sites and pilots, Educational trail - local and around Lodz

7. **Common access to information and data on environment:** Creation of a database, Interactive maps, Interaction of institutions/agencies such as the Crisis Management Centre.

8. **Investors and authorities respect the ecological conditions of land and water use:** Extend protected areas, Facilities to limit water consumption by residents, Pro-environmental investment as a condition for the sale of land, Broad scale landscaping for biodiversity preservation, Legal enforcement of pro-environmental behavior, De minimis programmes for environmentally friendly businesses, Adapting building regulations to comply with the ecological requirements, Reference document of natural values for local development plans, Creation of a system of consultation and promotion of developed visions, System of control of investment permits, Transparency for decision making process and involved decision makers.

3.3 Analyzing risk profiles of drivers and pressures to Łódź water resources.

In 2018 additional study has been carried to re-confirm factors selected as key drivers in meeting the vision of 2038. After Poland start to adopt EU regulations and transform towards open market, with simultaneous increasing access to European funds, the city management system and priorities started to evolve questioning the strategic goals selected in 2006.

The study involved citizens, who were asked to select the drivers that influence water resources the most, while the city officers were challenged with assessing them according to eleven features, creating risk profile of each factor (Fig.1.). Although economic growth and legislation remained on the top of the list, the factors were re-formulated to: low economic potential of the city and law enforcement. Additionally two more factors were added: land transformation and acquisition, and low environmental awareness of citizens.

The study indicated that in terms of legislation the problem lays in large spatial and economic scale it impacts different sectors and simultaneously involves them in creating the problem, as well as in persistence of the effects of lack of law obedience and time delay between the factor acting and its consequence being visible. Low economic potential jeopardizes achieving the vision through spreading the impact throughout a number of economic sectors and spatial scales, persistence of the risks, and high invisibility of the pressures until they lead to collapse of a number of activities. At the same time economy is a powerful tool mobilizing or demobilizing different parties. The economic problems have also tendency to accelerate, what makes them particularly dangerous with respect to efficiency of nature stewardship.

Both factors are interconnected, the weaker is local economy, the more prone the city is to neglecting some of ambitions and weakening some of restrictions and regulations, in favour of attracting new investment. This is reflected in particular by failure in meeting points 3, 7 and 8 of the strategy. Point 7 being affected by both limited resources to create data bank and limited willingness to make the information about environment transparent, especially when blue and green areas become a subject

of trade between city and investors, and land owners and investors, without recognition of the public good and long-term social and ecological benefits.

Similar risk profile has been developed for low ecological awareness of citizens with spatial and sectoral impact, persistence of effects, their irreversibility and acceleration of pressures being prevailing features. Interestingly, high awareness (profile marked with red line) was also perceived as risk to sustainable water management as civilian actions may hamper implementation of city plans. Perhaps this dichotomy laid at the root of the lack of strong awareness and education campaigns, declared in point 6 of the strategy.

3.4 The core of the strategy – Blue-Green Network

The fourth factor – high land transformation rate - hits the practical and operational framework for implementation of the Łódź' smart vision - its Blue-Green Network (BGN).

BGN builds on the valleys of 22 streams and rivers crossing the city on the way West and East, as Łódź is located on the watershed border of the Vistula and the Oder. Those valleys connect Łódź' green areas covering over 60% of the city surface. Those are forests, agricultural lands, gardens, parks, squares and cemeteries. Although 80% out of this area constitutes informal greenery – not marked as greenery in the city master plan – all together they form a consistent network, the field for operation of the vision 2038 and the strategies. The functions of BGN consists of ecological ones: water retention, protection of ground waters, habitats and biodiversity, plants and animals migration paths, microclimate regulation, and city ventilation, but also fit the targets of 0-emission and smart city: enabling green transportation, CO2 sequestration, emission control, connecting cultural and recreational areas and promoting healthy lifestyle, and interactions with nature.

BGN is highly endangered by land transformations, which according to risk profile impact its future in irreversible and persistent way, and occurs in large scale. The process accelerates, and characterizes with time lag between land change and seeing its consequences to water resources, and additionally information about it is not easily accessible, neither the cause-effect relationship well communicated to the society.

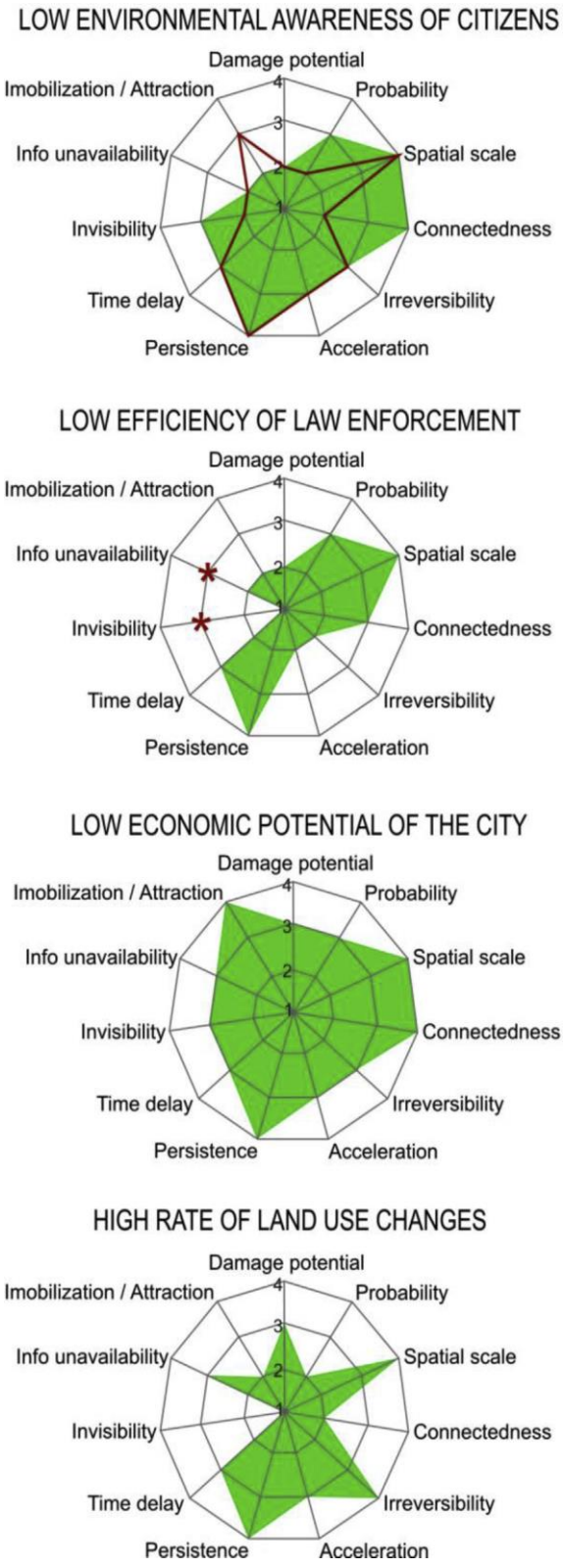

Fig. 1. Risk profiles of 4 key drivers of water resources in Łódź (Krauze, Włodarczyk-Marciniak 2018).

That threatens meeting the points 1-4 of the strategy ever, as the area to operate is shrinking fast and available land may not be able to buffer the impact. All the more, not all the locations are nature-friendly (poor soils, high temperature, limited water availability). In consequence simple NBS must be substituted with advanced ones – based on biotechnological innovations, phytoremediation, microbiology, ecological engineering. In short

nature-enabling NBS are needed to allowing nature and its services to enter the areas of the highest demand and the lowest supply.

As the most common reasons for not implementing the strategy mentioned by the Municipality include:

- Lack of good overview of the potential and problems;
- Lack of one, shared approach to city planning;
- Lack of pilot projects which could serve training in decentralized water management and mitigate the fears related to NBS application,

ATENAS:

1. landmarked the sites with high potential to regulate microclimate thus still able to secure ecohydrological NBS persistence and efficiency under climate change (Fig.2.).
   It raised discussion (at the city level) around land acquisition in several districts that appear to play a role in city cooling. It also made the situation visible and understandable to the publics raising awareness and supporting bottom-up initiatives (e.g. protests against transformation of airport neighborhood into private logistics centers);
   STEP TOWARDS STRATEGY POINTS: 1, 6, 8

2. carried the study of the rate of selling out the unbuilt (potentially occupied by informal greenery) municipal lots to developers (Fig. 3.), what revealed inconsistency in declared city goals and its actions towards (re)building the blue-green network;

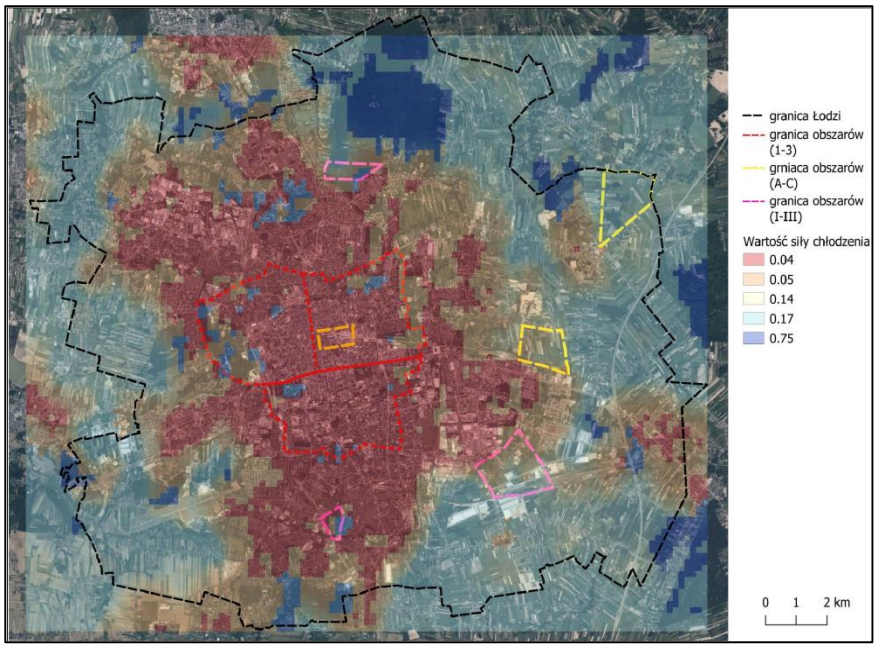

Fig.2. Cooling effect of the city of Łódź ecosystems modelled with InVest (Płóciennik 2021).

   It clearly indicated that BGN integrity is the most endangered in the areas where natural potential is the lowest, therefore every lot matters in the process of water management and climate mitigation. As site-effect it raised discussion about economics of the city actions as at the same time it sells out green patches to developers, and substitutes informal greenery with far less resilient street trees (without securing sufficient substrate neither water supply to allow them to sustain). Also the structure of city greenery (in-line planting, greenery in small patches separated by large impermeable surfaces, decorative non-native species, oversized trees comparing to root mass) makes it more urban furniture than NBS.
   STEP TOWARDS STRATEGY POINTS: 1, 3, 8

3. demonstrated use of different tools that supports sustainable urban drainage, like IRIP and blue-green factor, raising interest in application of the latter to evaluation of urban projects (https://mpu.lodz.pl/files/mpu/public/PROGRAMY_DZIELNIC/wskaznik_zieleni/wskaznik_zieleni.pdf);

STEP TOWARDS STRATEGY POINTS: 2, 3, 4, 8

4. visualized potential for supporting water regulation ecosystem services with IRIP model for the Łódka River catchment, clearly indicating that the intensity of runoff opens options to divert water among city greeneries as well as to supply drying Łódka River and store the surplus of water for flush droughts (Fig. 4.), and that many of frequently flooded areas are located near blue-green infrastructure able to serve as risk prevention NBS.
   STEP TOWARDS STRATEGY POINTS: 1, 4

5. constructed pilot water infiltration NBS nearby buildings addressing the main concern of the municipal departments that such solutions impose the danger to the infrastructure; the concerned lied at the roots of abandoning the programme of decentralized storm water management (e.g. projects of 100 rainwater gardens for schools and 150 façade gardens for the city).
   ATENAS brought know-how and demonstrated the approaches that minimize the risk.
   STEP TOWARDS STRATEGY POINTS: 1, 2, 5, 6

6. ATENAS demonstrated methods of engaging marginalized communities into the process of NBS planning and construction proving that such engagement is not only necessary but also possible.
   STEP TOWARDS STRATEGY POINTS: 6, 7

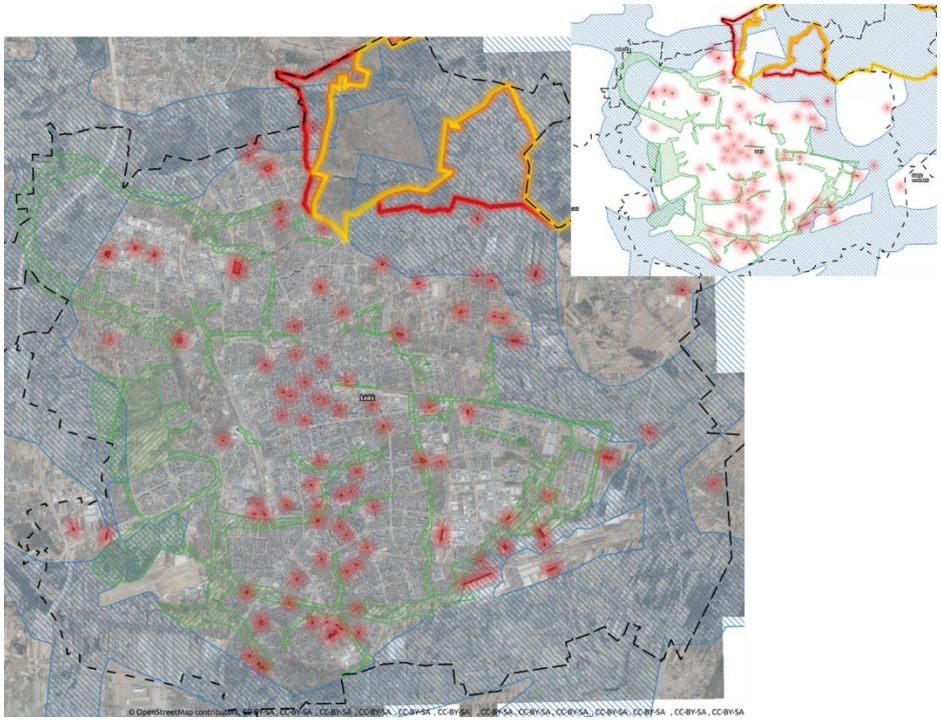

Fig.3. Areas of the highest rate of selling out the municipal unbuilt parcels (Rychlicki period 2020-2022).

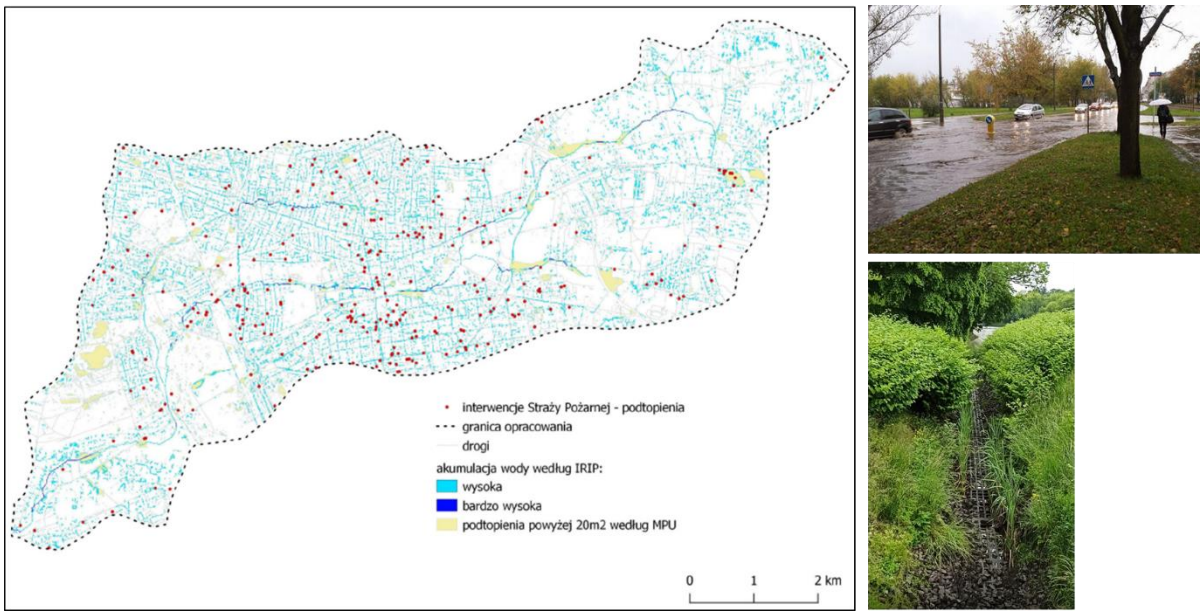

Fig.4. Runoff accumulation zones in the Łódka River catchment indicated by IRIP model – the accumulation mostly happens in the streets and on roads, while rivers and greenery are cut off of runoff with infrastructural obstacles (improper surface profiling, kerbs, location of storm water outlets).

3.5 New policy framework – potential roadmap to meet the Vision 2038

Strategic document	**Support for the vision**	**Items**	**Competitiveness to other priorities than nature & its services**
Development Strategy for Łódź 2020+	Themes: the city resistant to climate change & effectively shaping the space	0 emission, implementation of green deal, protection of spaces serving climate change adaptation, protection of biodiversity zones, water saving, protection of greenery in construction zones and its maintenance standards	LOW Legally not binding Acting more like recommendation and vision itself Giving green light to heavy investments rather than low cost solutions
Integrated Development Strategy for Łódź 2020+	Pillar: space and environment	Taking on the opportunities related to creation of the "Blue-Green Network", integrated into one functional, easily accessible, well connected with transport routes, coherent network of urban and metropolitan green areas; Operations and campaigns related to environmental education; Subsidiarity - taking actions through public private partnerships and public social partnerships;	LOW Only one item related to environment while the strategy has a strong focus on housing, transport infrastructure and attractive spaces, as well as technology development. Attractive public spaces & regeneration based on exploitation of nature do not support regulatory services being at stake. Selling out municipal lands for development does not promise protection of BGN.
Greenery standards in Łódź	Whole document	Dendrological inventory; protection of existing greenery in the investment areas; Ways to improve habitat conditions; aspects of public participation, educational function of green spaces	STRONG Potentially can regulate the management strategy for existing blue-green areas, and refers to maintenance of NBS
Municipal Revitalisation Programme of the City of Łódź	Operational goal: Promote the improvement of the quality and creation	Protect and nurture existing greenery, in particular tall and street greenery; Strive to increase biologically active areas in investments; Strive to	Potentially STRONG Revitalization is a high priority & high investment programme

	of public and semi-public (para-public) spaces arranged with the participation of residents.	compensate for deficits in homogenous parts of the revitalisation area in terms of public greenery of various types and social functions.	with potential for raising revenues related to NBS; However the emphasis on BGI & NBS is almost none, programme is not foreseen to cause impact on environment, what is surprising as refers to rebuilding infrastructure of the whole city center. No attention is given to water.
Ecopact for Łódź	Whole document	Strategic goals: development and protection of green spaces, protection and improvement of atmospheric air quality, rationalisation of water management, including rainwater management, Improving efficiency of waste management, developing new attitudes - educating children; PPP approach; Planning for economic leverages; Realistic list of success indicators;	WEAK The list of recommendations for voluntary participation; Unclear stimuli / gains for participation in Ecopact; Ambiguous and distributed competences and obligations involving many stakeholders
Strategy for spatial development of Łódź 2020+	Objective II: reducing urban sprawl Strategy item: Programme for public space quality improvement - Attractive City Spaces	Compensatory re-greening; Primarily developing sites already equipped with infrastructure; Limited development of infrastructural networks to only necessary additions; Protection of non-urbanized and environmentally significant areas; Stopping expansion of multi-family housing beyond the boundaries of Area of Contemporary Urban Core Development	MEDIUM Potentially beneficial for green ring, however programme for increasing investment in the Historic Urban Core and the Area of Contemporary Core Development mentions BGI in vague way as a “should be” rather than binding obligation; Water management is not mentioned in the strategy;

4. HELSINKI: SMART green visions – Nature-based solutions and their role in the Finnish Capital Region

4.1 Finnish Capital Region – Helsinki and Vantaa

Helsinki, the capital of Finland is the country’s biggest city with ca. 658 000 residents. The city is situated in the coast of Baltic Sea and the land surface is ca. 214,19 km^2 (total area 715.48 km^2 of which most is sea). Vantaa is the fourth most populated city in Finland with ca. 240 000 residents. The city of Vantaa encompasses 240.35 km^2, of which 1.97 km^2 is water. Helsinki and Vantaa belong to the Finnish Capital Region, which is the inner core of the Greater Helsinki metropolitan area. Both cities are growing fast, and the city scale zoning and land-use policy aims to produce enough apartments for new residents, create new working places, and develop transportation infrastructure in the way it supports sustainable modes of transportation. Compared to Central European countries, urbanization in Finland, one of most northern countries in Europe, is a relatively modern phenomenon (Eurostat, 2016). Although Helsinki metropolitan is the of most urbanized areas in Finland, a great deal of their land surface area still vegetated areas such natural, semi-natural and constructed

green areas such as forests, parks, agricultural land in Helsinki and Vantaa, 57 % and 75 %, respectively (Mäkynen et al. 2017, City of Helsinki 2017). Vantaa still has extensive forest areas as well as various aquatic environments, especially streams, which are also very valuable for biodiversity (City of Helsinki 2020, 2022). There are over 1,600 species found in Helsinki, 70 % of vascular plants recorded in Finland (Vierikko et al. 2014). The conservation value of forests is estimated to be high even at the national level, which makes its forests potential habitats for native species that could not survive in intensively managed commercial forests in rural landscapes (Vierikko and Jaatsi 2020).

It is predicted that climate change will bring significant change for seasonal landscape in Helsinki and Vantaa. If the mean temperature will rise 2-3 Celsius degrees, precipitation increases dramatically, especially in autumn and winter. More intense and common heavy rains in summer, but on the other hand also dry periods, will become more common. There would be only few if any freezing days in winter, and most likely runoff water and seawater floodings in Helsinki would cause damages for buildings and gray infrastructure. Climate change would have also impact on urban biodiversity and environmental conditions of water ecosystems in Helsinki and Vantaa. Unfreezing winter would increase pathogen and disease risks of urban vegetation, and leaching of nutritions, organic and soil matter from land surface would decrease ecological condition of water ecosystems.

Finnish legislation demand stormwater management actions from municipalities

The Finnish Land Use and Building Act was updated in 2014 with a new chapter (13a) on stormwater management. The municipalities are responsible for stormwater management in areas where a local detailed plan is in force. The general objectives of stormwater management specified in the law are as follows:
1) developing systematic stormwater management especially in areas where a local detailed plan is in force;
2) infiltration and detention of stormwater at the source;
3) preventing the impacts and damages to the environment and property caused by stormwater, while taking account of climate change;
4) promote giving up the practice to convey storm water into wastewater sewers.

The city of Helsinki published the first **city-wide stormwater management programme** in 2008 and the updated version in 2018. One of the key objective of the programme is that stormwater has been utilised for increasing the attractiveness of the environment, maintaining biodiversity and promoting a good condition of surface and groundwater. The programme has adopted a broader measure by preparing and developing catchment area - specific stormwater management plans for brooks and other areas for the purposes of detailed planning and further planning, and by using an ecosystem service- based blue green network planning tool in planning public areas and develops the tool. Also, local scale nature-based solutions are considered by reserving sufficient space for natural stormwater management systems in detailed plans. The programme also encourages to use green factor as a tool in detailed planning in order to determine the green efficiency of blocks.

As city of Helsinki, the city of Vantaa has published the **first city-wide stormwater management programme** already in 2009. The city will soon (in 2023 or 2024) publish updated version for the programme. In connection to the preparation of the stormwater program, the city ordered a small water survey for streams and ponds, a total of 67 objects. The survey included information about ecological quality of small water bodies, and management and restoration recommendations. One key aim of the programme was to develop **operational model of stormwater management** (City of Vantaa 2014). In the operational model five key principles are identified and one is that stormwater primarily,

stormwater is treated and utilized in the same way as the place of origin, using nature-based solutions. The aim is that the construction does not increase the flows leaving the site in comparison to the state before construction.
In addition to stormwater management strategies both cities have been active on developing city-scale strategies and roadmaps to support smart and green solutions in their cities. Firstly, we present visions of Helsinki followed by Vantaa.

4.2 Smart and Green visions in Helsinki

According to the City Strategy (2021-2025) Helsinki wants to be ambitious in climate responsibility, citizens' wellbeing, economic growth and nature conservation. In Mayors' words: *"The goal is for this common strategy to take us towards being a better city - towards evolving into a city whose objective is to enable a pleasant, enjoyable and sustainable life for every Helsinki resident*". City of Helsinki also aims to protect its wildlife and acts to increase the diversity of the urban natural environment. Helsinki's long-term adaptation vision is to be a climate-proof and safe city in an ecologically and socially sustainable way. A better and more sustainable city must also be prepared for the impacts of weather events and climate change (City of Helsinki, 2019). The city aims to be known as one of the global forerunners in climate change adaptation. The most significant impacts of climate change include sudden extreme weather events, such as torrential rains, strong winds and long heat waves and droughts. Helsinki's long-term adaptation vision is a climate-proof and safe city. This requires Helsinki to adapt to the changing climate well in advance and prepare for sudden weather events and the global impacts of climate change. To implement the adaptation vision, it is important to plan and build Helsinki to meet the requirements set by the future climate in the current situation.

Helsinki's long-term adaptation vision is to be a climate-proof and safe city in an ecologically and socially sustainable way. These visions are presented in the **Helsinki's climate change adaptation policies 2019-2025***.* A better and more sustainable city must also be prepared for the impacts of weather events and climate change (City of Helsinki 2019). The city aims to be known as one of the global forerunners in climate change adaptation. The most significant impacts of climate change include sudden extreme weather events, such as torrential rains, strong winds and long heat waves and droughts. Helsinki's long-term adaptation vision is a climate-proof and safe city. This requires Helsinki to adapt to the changing climate well in advance and prepare for sudden weather events and the global impacts of climate change. In order to implement the adaptation vision, it is important to plan and build Helsinki to meet the requirements set by the future climate in the current situation.

The city has already actively included adaptation in different programmes and created methods and tools. These include e.g. the Storm Water Management Plan and the Flood Strategy, the green roof guidelines and the green factor tool. The proposed measures will be included in the City's planning and guidance, for example in city planning, preparation and preparedness planning, the Storm Water Management Programme, the Flood Strategy, and the programmes for green area development and nature conservation and management (City of Helsinki 2019).
The Climate Adaptation Policy highlights that building green infrastructure and avoiding sealing the ground surface improves the stormwater management required by increasing precipitation, prevents the urban heat island event from intensifying and prevents nutrients and impurities from being transferred into water bodies. Preserving the diversity of the existing urban wildlife and nature plays an important role in achieving these goals. Helsinki promotes the adaptation measures of properties and residents by reducing the amount of stormwater by using nature-based solutions (City of Helsinki 2019).

Planning stormwater management comprehensively and with the water catchment areas are key goals in the adaptation strategy and a starting point for sustainable stormwater management. Secondly, planning and implementing primarily nature-based storm water management actions in accordance with the priority order of the Stormwater Management Plan of the city of Helsinki.
Adaptation measures of Adaptation Policies are integrated to land use and construction, education and teaching, nature management, recreation, social and health care services, industrial policies and preparedness and contingency planning. In the vision, developing green infrastructure and avoiding soil sealing are mentioned as key solutions for stormwater management and avoiding the urban heat island effect. Improving climate resilience would also enhance resilience of natural landscape. The climate adaptation strategy emphasizes that preserving the biologically diverse urban wildlife and nature plays an important role in achieving these goals. The measures of visions include, for example, development and mapping of urban green infrastructure at the city scale or even at the larger spatial scale. In addition, vision lists many measures such as increasing green structure, maintaining large trees, and planting new street trees and using nature-based solutions such as green roofs at the local scale planning (City of Helsinki 2019).

In the **Carbon-neutral Helsinki Action Plan for 2035** one measure to support use of NBS in detailed planning and in development of new residential areas is green factor tool. The green factor method, which was developed for the city of Helsinki, and which is currently used in detailed planning, is meant to ensure sufficient green structures and nature-based stormwater management in the detailed planning or at block level. The number of trees, bushes, and useful plants, particularly those that produce climate-friendly local food, should be increased (city of Helsinki 2018).

Furthermore, the city recently launched the **2nd Action Plan for Biodiversity (2021-2028)**. The aim of the plan is to take biodiversity into account in cross-sectorial decision-making and planning and preserve biodiversity also in the built environment and common green areas, not just in strictly protected areas with a clear vision for nature "*Biodiversity is cherished in the growing and changing city. Important green areas will be preserved and connections between them will be developed to support the well-being of their inhabitant species, as well as that of people*." According to the biodiversity action plan, the small water bodies of the city form important habitats, breeding and feeding areas, as well as passageways for different organisms, such as fish, invertebrates and plant seeds. Some of the creeks of Helsinki are home to the extremely endangered trout, whose populations have diminished due to poor water quality and emissions. To secure biodiversity, species occurring in Helsinki's small water bodies the city will strive to preserve the current semi-natural small water bodies, open swamps and wetlands. In addition, it will develop the shores of rivers and creeks as green connections that also serve as ecological connections and buffer zones for water bodies. The biodiversity action plan also support to build new, semi-natural storm water solutions in already built areas as well.

4.3 Smart and Green visions in Vantaa

According to the **City Strategy 2022-2025** among the most important challenges that the city is facing are climate change and the loss of biodiversity. The strategy highlights that the nature is close to residents' home and located everywhere: on streets, marketplaces, and private yards thanks to Vantaa's comprehensive green structure and nature reserves. As the areas become more compact, the city of Vantaa ensures that residents still have easy access (max. 300 meters) to recreation and green areas. The size and accessibility of green areas and their measurement will be analyzed. The strategy highlights that areas that have many trees and other vegetations are less vulnerable for extreme weather. Parks and street

green are implemented in densifying areas and the use of green efficiency is monitored. One of the key themes for years 2022-2025 is ecologically sustainable Vantaa. Vantaa is aiming to be carbon neutral by 2030 and securing its biodiversity but how the city will achieve the goals?

The Roadmap to Resource Wisdom (2018) is the main strategic document that aims to implement the city's goals for climate neutrality and biodiversity protection. Strategy has been built on six focus lanes: (1) **Urban structure and mobility**, (2) Carbon-neutral energy, (3) Lifecycle of materials and the circular economy, (4) **Biodiversity**, (5) Responsible Vantaa and (6) Carbon sinks and compensation. Specific indicators for each focus areas have been developed to monitor the achievement of the goals.

One of the important goals of **Urban Structure and Mobility Lane** is that the city aims preserving and increasing biodiversity in planning and construction and safeguarding the functioning of ecosystem services. This will increase the possibility to local nature-based solutions. In addition, the city will integrate climate change adaptation measures into planning, construction, and maintenance. The city enhances use of green construction in public areas, on privately-owned plots and on roofs to promote the management of stormwaters and temperatures. Introducing a plot-specific green efficient measures in all town plans will be supported.

The fourth lane of the Resource Wisdom is reserved for **Biodiversity**. It is acknowledged in the document that a rich natural environment produces important ecosystem services such as pollination, climate regulation and carbon sequestration, clean water, flood protection and recreation services. Two important goals for the lane are increasing, protecting and strengthening biodiversity in Vantaa in a systematic way, and improving the natural state and diversity of waterways. The city is also committed to continue the work to improve ecological quality of freshwater ecosystems in Vantaa. The aim is to reserve enough space for stream corridors in the land use planning of new development areas so that streams could naturally meander and maintain its natural condition.

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