Urban stormwater management using nature-based solutions

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Summary: The effects of climate change can also be observed in Hungary. Suddenly, heavy rainfall is more frequent, and periods of drought are longer. Managing the impacts of rainfall with changing intensity and distribution can be a major challenge for municipalities. The high proportion of paved surfaces further accelerates run-off. The stormwater drainage network is overloaded by the sudden arrival of large amounts of rainfall, which is discharged unused, sometimes causing severe damage through flooding. According to the findings of the UN Water Presidency, municipalities spend 90% of their financial resources intended for water damage reduction after disasters, reconstruction, and rehabilitation, while only 10% is spent on preventive measures and improving adaptive capacity. Prevention would be the preferred solution in the field of water management. Nature-based solutions in water retention are a suitable application for reducing exposure. Available different nature-based solutions: domestic rainwater storage, green roof or living roof system, green façade, permeable artificial surfaces, infiltration trenches and basins, trees and roadside green lanes. The primary objectives of our study are to provide an overview of nature-based solutions in the field of water retention and present the applied methods through case study of Nagykovácsi. The exposure of Nagykovácsi to flood-caused damage is high. Nature-based solutions offer promising opportunities for urban planning to provide a proper response to this challenge, including water management, flood protection, and adaptation to climate change.

Introduction

One of the most highlighted challenges for water management in Hungary and worldwide is to improve the efficiency of municipal water management. In recent years, experts have faced unprecedented water shortages. The sustainable management of available water resources is an important task in the face of increasingly extreme weather conditions and to prepare municipalities for environmental changes (Bartholy et al. 2011). The available freshwater resources (surface and groundwater) are very limited, and it is advisable to retain excess rainwater on the field using natural water retention methods and to use it during droughts. Among nature-based solutions, sustainable water retention methods provide an opportunity for efficient allocation and use of water resources (Cox et al. 1984).

Climate change is a permanent and significant change in the Earth's climate at the local or global level. It includes changes in temperature and the amount and distribution of precipitation. There is an exponential increase in the occurrence of extreme weather events, accelerating the hydrological cycle and fundamentally changing the local and temporal distribution of water. According to a study by the Hungarian Meteorological Survey, by mid-century, average annual surface runoff and usable water resources are projected to increase by 10–40% in some wet areas of Hungary and decrease by 10-30% in some dry areas that are already facing water scarcity. The size of areas affected by drought is expected to increase (Bihari et al. 2018). The frequency of intense rainfall will also increase, causing a higher risk of flooding. In recent years, negative records have been set in the water levels of domestic rivers. Lack of rainfall and heat waves have caused several small rivers to dry up completely.

As the extent of drought-affected areas increases, demand for water for irrigation and other domestic uses may also increase, especially in the summer. Conflicts may arise, not only over the amount of available water but also over access and water quality parameters. Integrated water management elements such as efficient stormwater management, water retention and wastewater recycling can contribute to mitigating climate change's consequences (Csorba 2021).

The EU Water Strategy sets out the following tasks to prevent water-related damage (European Community 2012, 2013, 2014): 1) to improve the resilience of aquatic ecosystems to climate change; 2) to coordinate the watershed management plans with the flood risk management plans for an integrated disaster prevention approach; 3) prioritising natural water retention measures; 4) encouraging water reuse.

Hungary's current water policy is set out in the Jenő Kvassay Plan, Hungary's National Water Strategy to 2030 (National Water Strategy 2017, European Community 2000), which aligns Hungary's water policy with the global sustainable development goals and domestic policy strategies.

It prioritises the management of urban stormwater, the elimination of untreated stormwater run-off and the establishment of stormwater quality management. It sets out the following objectives: 1) avoid or at least mitigate the emerging water-related problems; 2) make the most of our water assets; 3) maximize our security against risks from water surpluses or shortages; 4) to preserve water as an indispensable condition for life on earth and as an economic resource for future generations.

Based on the points mentioned above, the main objectives of the study are the following:

- Examining the current state of sustainable urban water management, regarding international and domestic water policies, domestic scientific research, and the global and local impacts of climate change.
- Make an overview of the used nature-based solutions in the field of sustainable water retention.
- Designation of a study area and identification of local regulatory and construction problems. Proposing natural water retention solutions, with possible intervention points.

In order to achieve the set objectives, the designated study area is the village of Nagykovácsi in Pest County, which could be representative of several surrounding hill and mountain settlements (Bodáné 2022, Csapák 2009).

General overview of nature-based solutions in water management

Municipal water management is a key area, providing drinking water for the residents, draining and treating wastewater, and disposing of water generated in settlements (Csapák 2009).

According to the National Water Strategy (2017), most municipalities are located in areas at risk of flooding, with high population density, accumulated wealth and high exposure to water damage from concentrated industrial activity.

There are some available solutions for these mentioned problems in the field of water management.

Green infrastructure is the use of natural and semi-natural areas to provide ecological and economic benefits to society by exploiting ecosystem services that support human quality of life. It complements or can replace the traditional "grey" infrastructure, which will continue to exist, but it highlights the need to modernise and transform the current systems, adding elements of green infrastructure.

A smaller percentage of precipitation runs off from natural areas because they retain more water than paved surfaces, from which most of it runs off and collects quickly, contributing to flash floods. In upland areas, there are some different solutions to slow down the flow of water: increasing the vegetation cover in urban areas (parks, recreational areas), increasing the number of green roofs and permeable surfaces. These measures can lead to prominent results.

The water retention capacity in the upper part of the catchment can be improved by building a reservoir and restoring the natural vegetation cover. Delaying runoff in lowland regions can also be a critical issue, although the smaller topographic differences favor infiltration more than in mountainous and hilly regions.

So, in the case of floodplains and wetlands, we should return to the original use of the landscape; after that, we should create artificial reservoirs in suitable areas for the future use of water. However, the best way to retain water is to support the very local infiltration, using the large natural water storage capacity of soils.

To prevent water damage, the primary concern is to ensure that sufficient free reservoir capacity is available to accommodate flash floods while storing as much water as possible in the reservoirs to cope with dry, droughty periods.

Búzás (2019) proposes three types of interventions according to the intensity of precipitation:

1. The small intensity of rainfall (up to 20 mm/h) should be kept within the catchment area, mainly through the construction of green infrastructure, and temporary delaying of run-off and siltation. This solution can work well if the catchment has good permeable soil and a low water table.
2. For rainfall of medium intensity (20–40 mm/h), green infrastructure options are not sufficient, as surface runoff also needs to be managed. The solution can be provided by permanent or temporary surface or underground reservoirs, using the drainage network and controlling surface run-off.

3. For extreme rainfall events (40 mm/h or more), grey infrastructure elements are explicitly required. It is assumed that the instantaneous status of the river basin is continuously monitored in real-time and the necessary interventions are carried out by means of remote-control structures installed at specific points in the basin. Mitigation or prevention of water damage can be achieved through the use of alternative surface runoff routes and temporary flooding areas.

Nature-based solutions: natural water retention

One of the most important challenges of sustainable water management is to achieve a well and sustainably operating stormwater management system that keeps rainfall in place by creating opportunities for its future use. As the artificial cover of surfaces increases, it causes not only an increase in the temperature, but also a limitation of the infiltration of precipitation. If a significant amount of precipitation cannot infiltrate, this part of the precipitation runs off the surface in a short period of time, causing flash floods. With the increase of paved surfaces, runoff rates have accelerated in settlements, with the majority of precipitation draining to surface or subsurface drainage systems. Also, this runoff water will be missed from the soil moisture content.

To reduce flood peaks and runoff coefficient, interventions at the local level, and green infrastructure elements will be needed to bring the catchment as close as possible to the natural conditions (Major 2021):

a) One of the first methods is domestic rainwater storage. The point of domestic rainwater storage is to keep rainfall that is falling (collectable) on your property in place. This way, the municipal drainage system is not overloaded and the collected water can be used locally for its purposes (garden irrigation, domestic water uses) (Matusz-Kalász 2019).
b) Another highlighted way is the green roof or living roof system. The purpose of green roofs is to ensure that roof run-off is not discharged into drains, but is used to water a special vegetation on the roof. We distinguish intensive and extensive green roofs. According to Mrekva (2019), a green roof can reduce the amount of stormwater runoff by 22–70% per year, depending on the type of vegetation planted on the roof: 1) Intensive green roofs, also known as roof gardens, are the most valuable type. Almost all plant species used in traditional gardens can be included in it. The construction and maintenance costs are higher than those of extensive green roofs; 2) Extensive green roofs use low-maintenance and low water-demanding vegetation. The advantages of this type are the low construction cost, water retention, and thermal insulation; 3) Blue roofs are particularly relevant in densely built-up urban environments. The method uses the reservoir capacity of the flat roofs, creating small pools on the roof surface. This way retains and evaporates large amounts of rainfall, reducing peak rainfall and the urban heat island effect.

c) The third commonly used method is the green facade. Also known as a green wall, it is an alternative solution where the plant cover is vertical, it can be used for almost any building. In summer, they help cool the urban spaces and buildings by shading. Two types are distinguished: natural green walls and artificial green walls: 1) Intensive green roofs, also known as roof gardens, are the most valuable type. Almost all plant species used in traditional gardens can be in it. The construction and maintenance costs are higher than those of extensive green roofs; 2) Extensive green roofs use low-maintenance and low water-demanding vegetation. The advantages of this type are the low construction cost, water retention, and thermal insulation.

d) The next urban solution to retain water is permeable artificial surfaces. It has similar strength characteristics to traditional road and pavement structures, but is porous in design, resulting in it permeable and allowing water to seep through the pavement.

e) Infiltration trenches and basins are widely used methods. Three types of stormwater drainage and storage systems combined with infiltration can be distinguished: vegetated channels, infiltration trenches, and rain gardens (also known as bioretention facilities). A common advantage of them, they promote infiltration while passing rainwater through a filter layer, thereby removing pollutants. In addition to purifying water, they also reduce the speed of run-off: 1) Vegetated channels are unpaved, grassed ditches, shallow drainage channels covered with vegetation, in which a part of the run-off water infiltrates into the soil; 2) Infiltration ditches differ from vegetated channels in that they are lined with gravel or stone instead of vegetation, thus requiring less space; 3) Rain gardens are artificially created depressions covered with native plants and grass to temporarily hold and infiltrate rainfall, preventing run-off.

f) Trees and roadside green lanes are very important parts of the methods used. Trees decrease the erosion effect of intensive rains by interception, absorbing dust, and evaporating precipitation over large areas, cooling the air in their immediate vicinity by up to 10 °C, and they are a valuable component of the urban climate and ecosystem.

Water retention in the upper part of a catchment

Potential reservoirs are mainly found in mountainous and hilly areas in the upper part of a catchment. Besides surface water storage, relying on the water storage capacity of soils is important, especially in agricultural areas.

Log dams are an effective way of combating flash floods. A cross-barrier constructed log dam from locally harvested woody vegetation diverts a significant proportion of runoff to areas surrounding the intermittent flow during the initial stages of the pooling process, where temporary water cover does not cause damage, thus increasing the pooling time and flattening the flow.

Restoring watercourses to their natural or semi-natural state is also an important objective. The practice in the 20th century was to cover many watercourses with grey infrastructure interventions, lining them with concrete and other artificial structures to reduce flood damage and ensure the safety of agricultural production. These interventions have accelerated run-off by decreasing the roughness of the surface and reducing the biodiversity of the local fauna and flora. By removing concrete revetments and all man-made structures and creating natural replacements, the riverbed can be restored to its natural state.

Land use change is also essential to get the original, near-natural state of the landscape. The options for intervention are manifold. Land-use change aims to stop intensive agricultural production in the floodplain by decreasing the regular drainage channel network, thereby supporting the restoration of traditional floodplain management practices, including wetland creation.

Water storage is one of the most important parts of the whole water system. We distinguish two basic types of reservoirs: permanent and temporary. Permanent reservoirs are those that reduce the flood peak locally. Other substantial types are the low and medium-storage capacity reservoirs, which will be constructed in many parts of the catchment area to retain rainwater and make subsequent use of the stored water. Intermittent reservoirs are stormwater reservoirs and emergency reservoirs. The stormwater reservoirs are located in the catchment area in the most favorable locations for the collection of water and are capable of moderating flood levels by transversely blocking the valley and regulating the flow.

Materials and methods

Based on experiences gained in a hilly environment (Püspöszilágy), we have chosen the village of Nagykovácsi in Pest County as a study area, which can later be a representative of several surrounding hilly and mountain settlements (http1, http2).

Two projects started in Hungary, granted by different LIFE programs, targeted local water retention measures by using nature-based solutions (LIFE MICCAC and LIFE LOGOS4WATERS). The main objectives of these projects were the potential adaptation of natural water conservation solutions, improving the resilience of municipalities to climate change, and reducing the risks of climate change. The projects have been implemented in 5 locations in Hungary, adapting natural water retention solutions: Bátya, Püspökszilágy, Ruzsa, Rákócziújfalu and Tiszatarján. A hilly water catchment environment is demonstrated by Püspökszilágy, while the other four villages are located in plain areas.

Nagykovácsi can be found just a few kilometers northwest of the capital, Budapest. It is located in the Budai mountains and is built of carbonate rocks (Csorba 2021). The settlement takes place in a relatively high geographical position, where the valley floor is at an altitude of about 300 m above sea level, while in some parts it reaches 400–450 m (Csapák 2009). Most of the forests are protected by law and the ground cover is not subject to strong physical-chemical impacts, except in the most popular hiking areas (Csorba 2021).

The microclimate of Nagykovácsi is wetter and cooler than the surrounding areas, with a moderately warm and dry climate, and a moderately cold climate in the higher areas. However, due to its geographical location, it is more exposed to extreme weather conditions. On hillsides, flash floods caused by heavy rainfall pose a serious threat. Summers are getting warmer and there are significant changes in the distribution of precipitation (http3, Pongracz 2011). While the yearly average temperature in the capital is around 11–12 °C, in Nagykovácsi it is around 9.5–10 °C (Figure 1). Annual average precipitation is between 600 and 650 mm, dropping below 400 mm in drought years and exceeding 900 mm in wetter years (Figure 2, http4).

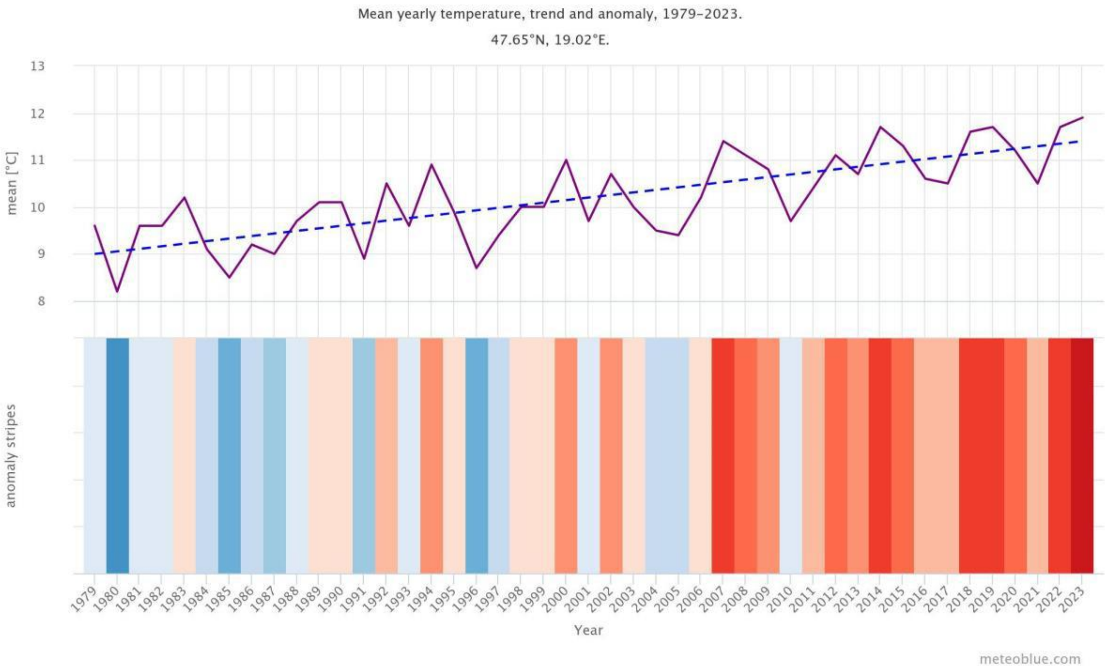

Figure 1. Changes of annual temperature in Nagykovácsi from 1979 to 2023, the horizontal axis indicates years, the vertical axis indicates mean annual temperature (Source: www.meteoblue.com, 2024)

1. ábra. Nagykovácsi éves hőmérséklet-változása 1979-től 2023-ig, a vízszintes tengely az éveket jelöli, a függőleges tengely az éves középhőmérsékletet (forrás: www.meteoblue.com, 2024)

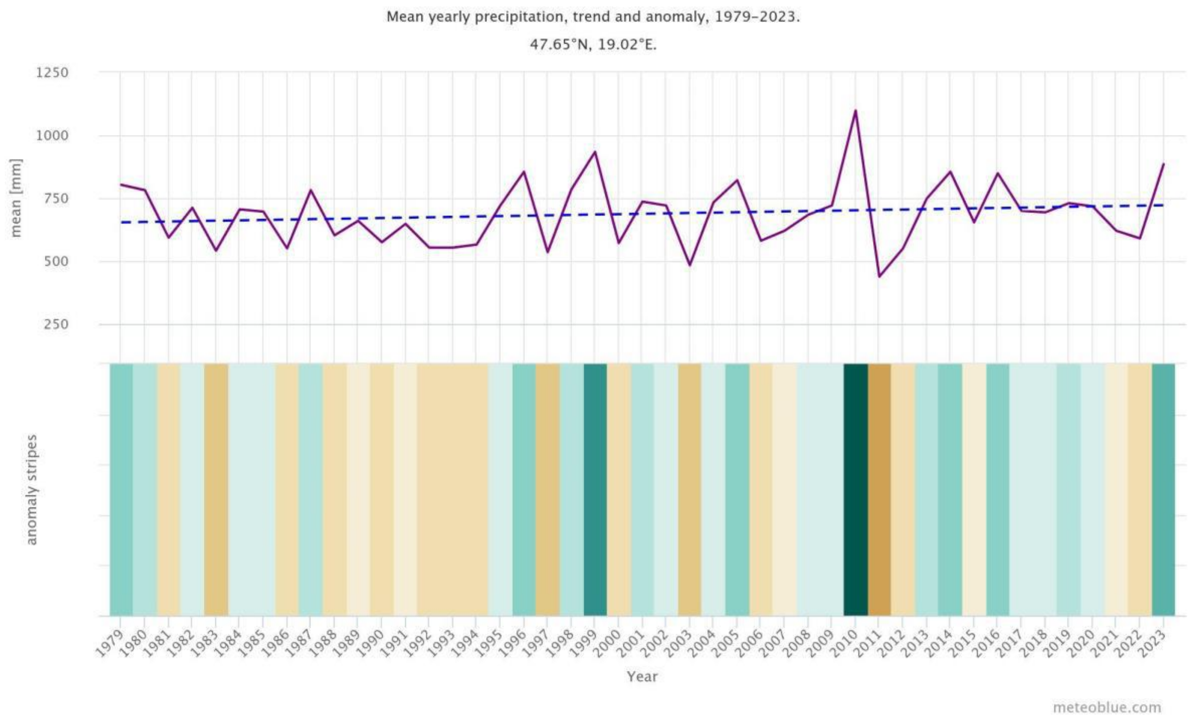

Figure 2. Changes of annual precipitation in Nagykovácsi from 1979 to 2023, the horizontal axis indicates years, the vertical axis annual precipitation (Source: www.meteoblue.com, 2024)

2. ábra. Nagykovácsi éves csapadék változása 1979-től napjainkig, a vízszintes tengely az éveket jelöli, a függőleges tengely az éves csapadékmennyiséget (forrás: www.meteoblue.com, 2024)

Nagykovácsi is almost entirely within the catchment area of the Ördög ditch (Csapák 2009). The amount of precipitation is collected by the ditch, which is not a permanent watercourse and often dries up, especially in summer (Csapák 2009). The catchment area of the Ördög ditch is 76 km^2 and runs for more than 20 km from its source to the Danube. During drought periods, especially in autumn, it often dries out completely, while during the rainy periods of late spring and early summer, the water flow can reach up to 45 m3/s. In terms of wastewater drainage, the settlement is completely sewered. During our field trip (October of 2023) to explore natural and man-made features of the settlement, we encountered the following problems:

1. The upper section of the stream has dried up, including Lake Békás, which is part of the stream (Figure 3).
2. Water was observed only in the inland areas.
3. The riverbed is full of sediment, clogged in many places.
4. Many smaller bridges cross the riverbed, which provide access to the properties. Under these bridges, pipes of different diameters have been installed to let the water go under. In some cases, these passages were not clean, obstructing water flow (Figure 4).

Figure 3. The dried up Lake Békás, October 2023 (Source: Júlia Anna Sebestyén, 2023)

3. ábra. Kiszáradt Békás-tó, 2023. október (forrás: Sebestyén Anna Júlia, 2023)

Figure 4. Examples of the problems in the Ördög Ditch: on the left is the dry upper section, on the right the sediment-filled bed (Source: Júlia Anna Sebestyén, 2023)

4. ábra. Példák az Ördög-árok problémái közül: bal oldalon a kiszáradt felső szakasz, a jobb oldalon a hordalékkal teli meder (forrás: Sebestyén Anna Júlia, 2023)

While the probability of natural damage events occurring is small, the devastating impact is mainly due to intense rainfall and wind. Between 1931 and 2015, there were nearly 30 years of severe drought in the region. Nagykovácsi has been hit by flash floods several times in the last 10–15 years, causing significant damage. The natural or built environment is often damaged, roads, bridges and houses can be damaged, micro- and macrofauna can be destroyed, and agriculture can be negatively affected by losing topsoil. Damage restoration can involve high financial costs. Mountain, hilly, and urban areas are particularly vulnerable to this kind of disaster. Significant erosion effects can also be observed in sloping areas. In built-up areas, impermeable layers (asphalt) are blocking water infiltration. Drainage is influenced by land use, vegetation, soil type, and soil water content (Ruin et al. 2008).

Due to its geographical location, Nagykovácsi is particularly exposed to the effects of extreme weather events. There is an increase in the intensity of precipitation. Thunderstorms can bring up to 80–100 mm of precipitation, which generates flash floods (Nagykovácsi Nagyközség 2021). Nagykovácsi has won a grant that can be used to retain rainwater, build stormwater reservoirs and drill wells, and clean up old wells to improve water security in the municipality.

As it was mentioned above, Püspökszilágy provides a best practice for Nagykovácsi. What kind of measures were taken there? In the case of Püspökszilágy, adaptation to climate change has been achieved through flood protection based on run-off attenuation and water retention. To slow the runoff and water retention, log dams have been built on two tributaries of the Szilágyi stream to slow the flow of water and flatten the floodwaters. A side reservoir has also been created in the lower catchment, which can absorb excess water and serve as a wetland. The complex solution aimed to reduce the risk of flash floods and retain water resources within the municipality, thus ensuring water supply in times of drought and mitigating the expected adverse effects of climate change (Veres et al. 2021)

In a previous study, Alex Csapák used a questionnaire survey method to investigate the stormwater management habits of households in Nagykovácsi. His results showed that 46% of households collected rainwater at that time. In the village, 132 cisterns and 81 other simple storage facilities were used to store rainwater, resulting in a total volume of 1,258 m3 of rainwater storage. He estimated the volume of rainwater that could be stored and used by the population at around 78 000 m3/year, which means that this method of water use has a potential of almost eight times more. The study also looked at how rainwater is managed. It found that 97% of households used the stored water exclusively for irrigation, with some using it for other, higher-level household needs. The latter was well supported by the fact that the analysis of the doctoral thesis showed that the rainwater, roof water and cistern water samples taken in Nagykovácsi were characterised by very favourable water quality parameters and that the duration of the storage did not significantly affect the water quality. Almost 60% of the respondents who did not use piped drinking water for irrigation had a significant alternative source of water (49% had a well and 10% had a cistern). Only 18% of the properties surveyed had a well. The water from wells was used for irrigation by 75%

of the respondents, and 12% (five households) for drinking or other household water uses (Csapák 2009).

Results and discussion

Making an overview of the local regulations related to water and nature-based solutions was an important part of the study. Examining the local regulations regarding water management issues, we found some forward-looking points:

1. Section 8 (2) (b) of the Urban Development Plan stipulates that the protection of natural riparian vegetation and natural habitats must be ensured during the planning and construction of surface watercourses and streams, and the placement of new structures. Water management shall be implemented with or without minimal bank encroachment, using engineering-biological-technical solutions. This provision, therefore, favours the use of nature-based solutions.
2. Article 10(6) of the Urban Development Plan requires the construction of a reservoir or a percolation structure to manage stormwater runoff from within the plot, recognising the need for the public to have the opportunity and important responsibility to reduce runoff. To this, Article 22(4) adds that, in the case of an extension of the paved surface of a plot, the size of the on-site stormwater reservoir must be increased so that for every 50 m^2 of paved surface area started, a minimum of 1 m^3 of local stormwater storage volume must be provided.
3. Paragraph (1) of Article 17 of the Urban Development Plan stipulates that tree belts and tree shelters must be planted along surface watercourses and major drainage ditches, as they also play a significant role in regulating the microclimate and evapotranspiration, the direct release of water resources into the atmosphere, and in regulating the groundwater level.
4. In addition, according to Article 19 (7) (b) of the Urban Development Plan, the drainage of roads with a regulatory width of less than 8 m must be solved using a gutter or the construction of a closed storm drain, which unjustifiably predicts the continued existence of grey infrastructure.

Despite its internal inconsistencies, the local regulations presented here show a generally correct approach to water management. What is objectionable, however, is the observance and enforcement of the rules. The stormwater reservoirs provided for in the urban development plan have not been built, nor have the tree-lined areas that are supposed to provide protection. The majority of the population immediately discharges rainwater on their land into the public area or, in the worst case, into the public sewer system. Based on our field experience, considerable public awareness-raising and consistent enforcement of modern standards are still needed before a forward-looking local regulatory environment can be put into practice.

Any intervention in the countryside must be planned and carried out with particular care, given that they all affect a nature reserve. Based on the considerations, the case study mentioned above, and also the experiences of our field trip, some technical solutions can be proposed to retain rainwater, as follows:

1. Some of the rainfall from the surrounding hills can be absorbed naturally by the soil, but in the event of heavy or prolonged rainfall, it will put a strain on the drainage system of the municipality. In the higher elevations of the catchment, several locations can be identified on the northern and southern hillsides where log dams can be used to reduce runoff. Possible locations: Zsíros-mountain, Nagyszénás, Nagy-Kopasz mountain (taking into consideration nature protection rules, if they exist there).
2. A stormwater reservoir could also be built on the slopes of the Nagyszénás and Nagy-Kopasz mountains in the more hilly parts of the basin (taking into consideration nature protection rules, if they exist there).
3. Rain gardens, also called bioretention facilities, are one of a variety of practices designed to increase the infiltration of water.
4. Establishment of a valley barrier reservoir in one of the two valley areas in the western part of the basin.
5. Application of permeable pavement types in the settlement. According to Csapák (2009), before 2010, Nagykovács had about 135000 m^2 of paved and 108000 m^2 of unpaved roads. To alter these roads into permeable pavement type might have a high cost, but a benefit can be to reduce damage by flash floods since a significant amount of precipitated water can infiltrate into the soil.
6. The use of infiltration trenches in the area. Infiltration trenches can play an effective role in the planning area where the trenches are almost parallel to the contour lines, because this is where the greatest residence time and the chance of infiltration is encountered.
7. Rehabilitation of a small watercourse in an inland area. The state of the Devil's Ditch, which runs through the municipality, is far from being considered close to nature, especially in the inland section. The riverbed has been narrowed and its natural floodplain has been built up. Narrow, high-threshold bridges and culverts are common.
8. The use of domestic rainwater storage solutions. During the on-site visit, one of the biggest problems was the rainwater accumulated on the roofs and led directly to the ditch. To solve the problem needs not just financial resources, but

awareness-raising, too. The objective is to collect all possible rainwater in the private properties (gardens).

Proposal for the use of nature-based water retention solutions

Some of the rainfall from the surrounding mountains can be naturally absorbed and stored by the soil, but in the event of heavy rainfall, it will put pressure on the drainage system of the municipality, since the water storage capacity of the soil might not be enough. In the higher parts of the catchment, on the northern and southern hillsides, several places can be identified where log dams can be used to reduce runoff. These sites are typically deep valleys or gullies, the length of many of which allows the formation of staggered log dams. For example, there may be opportunities to build log dams on the sides of Zsíros Mount, on the sides of the Nagyszénás and Nagy-Kopasz (taking into consideration nature protection rules, if they exist there).

On the flat parts of the catchment, for example, on the slopes of the Széna Mountain and the Nagy Kopasz, building a storm reservoir could be an option.

In the western part of the catchment, two valley areas may be suitable for creating a valley-barrier reservoir. The reservoir can provide a continuous water supply during drought periods for both the Békás Lake and the Ördög Ditch.

Permeable pavements should be used for planned road construction to avoid unnecessary increases in runoff and the potential of flash floods. Drainage ditches are also typical along paved roads in Nagykovácsi. These were built with a traditional engineering approach using prefabricated bund elements. Due to the topography and steep slopes, these ditches generate high water velocities in extremely wet weather, which are beyond the design limit. The negative impacts could be mitigated by replacing the existing concrete pavements with trenches that allow water to infiltrate. This solution partly reduces the runoff, as water can infiltrate into the soil, and partly dampens the water velocities due to the higher bed roughness. Nature-based water retention solutions offer more sustainable opportunities for urban planning, including water management, flood protection and adaptation to climate change.

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References

Bartholy J., Bozó L., Haszpra L. 2011. Klímaváltozás - 2011 - Klímaszcenáriók a Kárpátmedence térségére, Budapest, MTA, p. 281.

Bihari Z., Brezsnyánszky K., Csorba P., Fekete G., Gábris Gy., Haas J., Horváth G., Kerényi A., Király G., Kocsis K., Molnár Zs., Pásztor L., Schweitzer F., Szabó J., Szabó M., Tardy J., Timár G., Varga Gy., Varga Z. 2018: Éghajlat. In: Kocsis K. (főszerk.) 2018. Magyarország Nemzeti Atlasza – Természeti környezet. MTA CSFK Földrajztudományi Intézet, Budapest. pp. 58–69.

Bodáné Dr. Kendrovics R. 2022. Nemzetközi és hazai példák a körforgásos vízgazdálkodásra. Magyar Víz - és Szennyvíztechnikai Szövetség, 4. lapszám, Budapest pp. 69–84.

Búzás K. 2019. Csapadékvíz Gazdálkodás a Településeseken. BME, Vízi Közmű és Környezetmérnöki Tanszék, Előadás, Lajosmizse 2019. június 19.

Búzás K. 2019. Települési Csapadékvízgazdálkodás: Tervezési szempontok módszerek a jövőben. Előadás Tatabánya 2024. december 4.

Csapák A. 2009. Települési vízgazdálkodás, lakossági csapadékvíz-gyűjtés és felhasználás. ELTE Természettudományi Kar, Budapest. p. 155.

Csorba P. 2021. Magyarország kistájai. Meridián Táj- és Környezetföldrajzi Alapítvány, Debrecen. p. 416.

Cox V., George S. F., Ruth K., Peter R. L., Edward R. R., Durward L.A., Rhodes W. F., William C. S., 1984. ABC's of nature, The Reader's Digest Association Inc., New York. p. 327.

European Community 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal of the European Parliament, L327. pp. 1–82. DOI: https://doi.org/10.1039/AP9842100196

European Community 2012. A Blueprint to Safeguard Europe's Water Resources, Brussels, 14.11.2012 COM (2012) 673 final

European Community 2013. Green infrastructure (GI): enhancing Europe's natural capital, Brussels, 06.05.2013 COM (2013) 249 final

Európai Számvevőszék 2014. Különjelentés: Az uniós vízpolitika célkitűzéseinek integrálása a KAP-ba: részleges siker, Az Európai Unió Kiadóhivatala, Luxembourg. p. 68.

Nemzeti Vízstratégia 2017. Kvassay Jenő Terv, Belügyminisztérium, Budapest. p. 140.

Major A. 2021. Ijesztően gyors lehet Magyarországon a klímaváltozás: 20–30 év múlva kritikus szintre emelkedhet a hőmérséklet, Portfolio 2021 augusztus 13.

Matusz-Kalász D. 2019. Családi Ház Esővízgyűjtő Rendszerének Méretezése, Multidiszciplináris tudományok, 9(2): 43–49

Mrekva L. 2023. A városi csapadékvíz-gazdálkodás hatékonyságát befolyásoló okok, Védelem Tudomány 8(3): 91–102., DOI: https://doi.org/10.61790/vt.2023.13038

Nagykovácsi Nagyközség 2020. Helyi Klímastratégiája 2021–2030, REevolutio Consulting Bt.

Pongracz R., Bartholy J., Miklos E. 2011. Analysis of projected climate change for Hungary using ENSEMBLES simulations; Applied Ecology and Environmental Research 9(4): 387–398, DOI: https://doi.org/10.15666/aeer/0904_387398

Ruin, I., Creutin, J.-D., Anquetin, S., Lutoff, F. 2008. Human exposure to flash floods – Relation between flood parameters and human vulnerability during a storm of September 2002 in Southern France. Journal of Hydrology 361: 199–213. DOI: https://doi.org/10.1016/j.jhydrol.2008.07.044

Veres D., Fejes G., Danyi R., Halmai L., Hegyi Z. 2021. Vízmegtartó megoldások a hazai vízgazdálkodásban, Országos Vízügyi Felügyelőség, Budapest. p. 77.

Referenced laws and regulations

A természet védelméről szóló 1996. évi LIII. törvény

A védett és a fokozottan védett növény- és állatfajokról, a fokozottan védett barlangok köréről, valamint az Európai Közösségben természetvédelmi szempontból jelentős növény-és állatfajok közzétételéről szóló 13/2001. (V. 9.) KöM rendelet

28/1994. (V. 20.) Alkotmánybírósági határozat

Online sources

http1: https://lifelogos4waters.bm.hu/dokumentumtar/ (Hozzáférés / accessed: 2025. 06.)
http2: https://puspokszilagy.hu/projektrol/ (Hozzáférés / accessed: 2025. 06.)

http3: https://www.portfolio.hu/global/20210813/ijesztoen-gyors-lehet-magyarorszagon-a-klimavaltozas-20-30-ev-mulva-kritikus-szintre-emelkedhet-a-homerseklet-496194 (Hozzáférés / accessed: 2025. 06.)
http4: https://www.meteoblue.com/hu/climate-change/nagykov%C3%A1csi_magyarorsz%C3%A1g_3047646 (Hozzáférés / accessed: 2025. 06.)

Természetalapú megoldások a városi vízgazdálkodásban

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Kulcsszavak: fenntartható fejlődés, vízkörforgás, természetalapú megoldások, vízvisszatartás

Összefoglaló: Az éghajlatváltozás mára vitathatatlan, hatásai hazánkban is megfigyelhetők. Gyakoribbak tehát a hirtelen lezúduló, nagy mennyiségű esőzések és hosszabbak az aszályos időszakok. A települések számára komoly kihívást jelenthetnek a megváltozott intenzitású és eloszlású esőzések hatásainak kezelése. A burkolt felületek aránya magas, ami még jobban gyorsítja a víz lefolyását. A csapadékvíz elvezető hálózatot túlterheli a hirtelen érkező nagy mennyiségű csapadék, ami hasznosítatlanul távozik a területről, bizonyos esetekben súlyos anyagi kárral járó elöntéseket okozva. Olyan megoldásokra kellene törekedni, amik a megelőzést helyezik középpontba. Költséghatékonyság szempontjából is kedvezőbb a kármegelőzés, mivel általa kevesebb az elfolyó vízmennyiség, az árhullámok ellaposodnak, mérséklődnek vagy akár elmaradnak, s ezzel csökkennek vagy megszűnnek a károk. Erre remek lehetőséget adnak a természetes vízmegtartó megoldások. Nagykovácsi vízkároknak való kitettsége többrétű. A természetes vízmegtartó megoldások a várostervezés számára többek között a vízgazdálkodási és árvízvédelmi feladatokra, valamint az éghajlatváltozáshoz való alkalmazkodásra kínálnak lehetőséget.