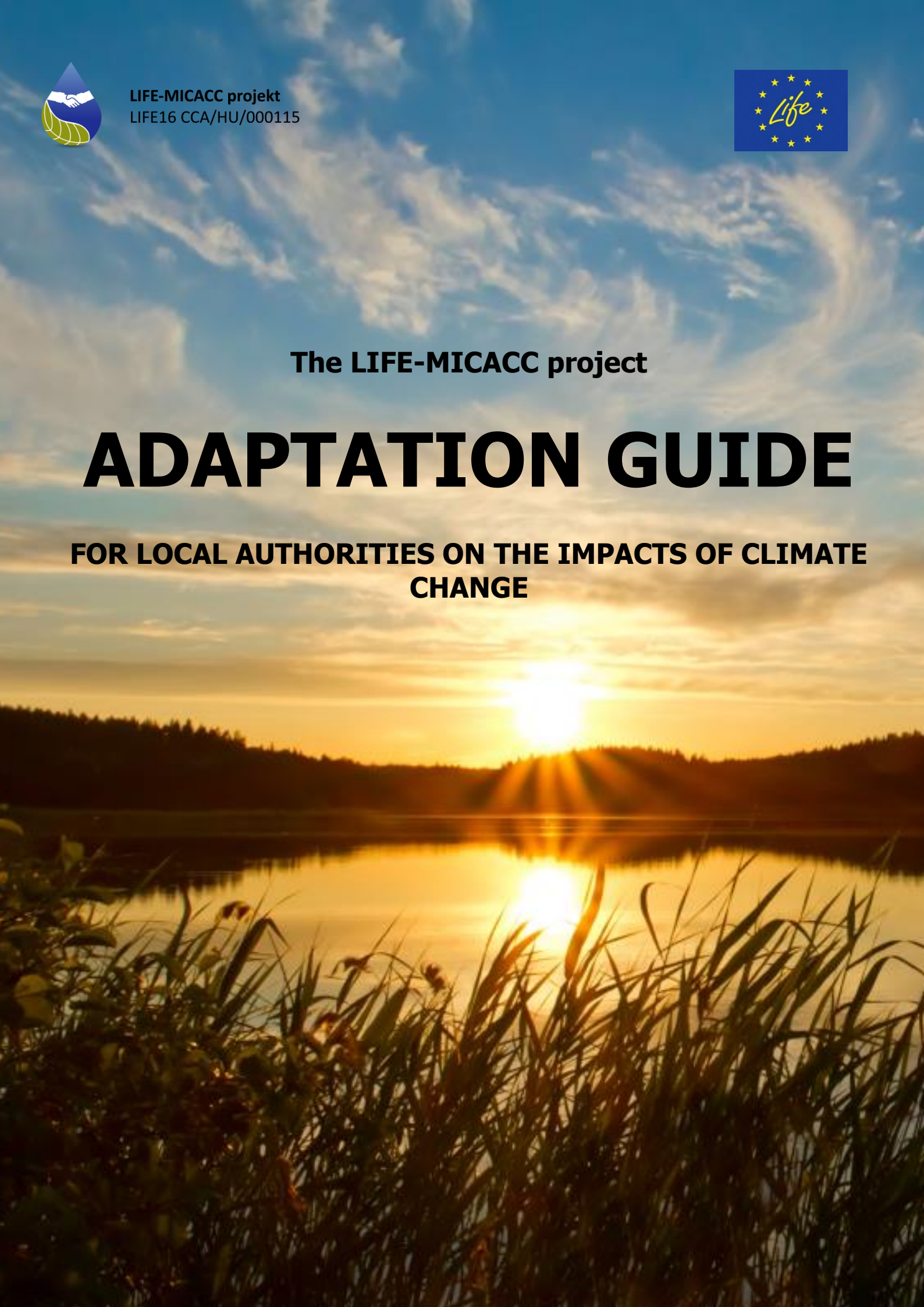

LIFE-MICACC projekt
LIFE16 CCA/HU/000115

The LIFE-MICACC project

ADAPTATION GUIDE

FOR LOCAL AUTHORITIES ON THE IMPACTS OF CLIMATE CHANGE

ADAPTATION GUIDE

for municipalities,

prepared under
Project No. LIFE16 CCA/HU/000115 LIFE-MICACC,

with the identification number LIFE16 CCA/HU/000115,

titled "Municipalities as integrators and coordinators in adaptation to climate change"

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Budapest, 2021

Table of contents

GREETINGS

Photo: András Jóri

I am proud to see that the LIFE-MICACC project which was launched on 1 September 2017 has reached another milestone, and to be able to offer you this Adaptation Guide, prepared on the basis of the lessons drawn from the implementation of the project so far. This aid has been prepared specifically for municipalities but I am sure it should be a useful source also for others interested in matters relating to water retention and local adaptation.

2020 was a year of challenges for us all and showed how important adaptation to, and preparation for, a given (unexpected and unfavourable) situation is. Climate change is a phenomenon whose impacts we all experience directly, in our towns and villages too. Taking all necessary steps to mitigate the negative impacts of climate change is not only an option to contemplate but also our shared responsibility and duty. The most efficient and effective way to do so is through preparation and adaptation.

In this publication we describe the role and possible actions of municipalities in the process of adaptation to climate change, we discuss possible methods of water retention detailing and illustrate through practical examples the advantages of the various natural water retention solutions, effective methods and means for the involvement of stakeholders, and present recommendations regarding communication and the dissemination of information.

The primary purpose of this guide is to encourage and support municipalities in implementing similar solutions in their respective communities (appropriately adapting them to the locally faced climate challenges and the local conditions). With the Guide we aim to provide a practical and useful aid and methodology for these efforts.

I wish you a good reading!

Sincerely,

Dr. Miklós Dukai

Deputy State Secretary for Local Government of Hungary's Ministry of Interior.

EXECUTIVE SUMMARY

To the Adaptation Guide prepared under the LIFE-MICACC project

The LIFE-MICACC project is Hungary's first project implemented with funding awarded under the LIFE Climate Policy Subprogramme.

The preparation and implementation of the project entitled "**Strengthening municipalities' role as integrators and coordinators in adaptation to climate change**" is a result of a broad partnership effort, coordinated by the ministry in charge of municipalities, that is, the Ministry of Interior, comprising a total of 10 partners, including five domestic municipalities.

We have gathered and combined information, experiences and achievements relating to natural water retention solutions designed and implemented by the five municipalities under the LIFE-MICACC project. These results, and the body of information and experiences accumulated during the preparation, design, execution, the processes whereby the necessary authorisations and licences were obtained as well as the operation of the facilities and structures are presented in detail in this Adaptation Guide. **The Guide is aimed to be used as an aid by municipalities wishing to implement similar solutions for their own towns or villages.** We aim to help them in such efforts by providing advice, recommendations, good examples and useful information. This is how we wish to encourage the implementation of more and more similar natural water retention solutions in Hungary and outside her borders.

To this end, **in the four chapters of the Adaptation Guide we present the following topics, outlined in brief in the sections below**, for representatives of as well as for professionals and others interested in this specific field.

Chapter 1 - Climate change and possible actions to be taken by municipalities

The most clearly perceptible effects of climate change in the Carpathian Basin are changes in hydrological conditions, besides temperature variations. We are bound to be faced with **more and more extreme water-related climatic risks and hazards** such as droughts, floods, heavy rains, waterlogged fields, sometimes alternatingly. These **may cause massive problems for any municipality**, threatening municipal property and assets, the daily lives of residents and the reliable operation of local businesses. Increasingly heavy damage may be expected to be caused by water both within and outside the administrative boundaries of municipalities. Towns and villages in the Hungarian plains which used to be our large rivers' floodplains, are simultaneously threatened by inland excess water, floods and droughts. The main source of danger facing towns and villages in hilly areas comes from flash floods. At times there is too much water (flood, flash flood, inland excess water in waterlogged fields), while at other times there is a shortage of water (drought). The best **solution is evening out excess and shortage, to the extent possible**.

Although climate change is a global phenomenon, it has profound local impacts as well, making local adaptation imperative. **Municipalities play a key role in preparations for, and in local adaptation to, the likely impacts of climate change.** The reason municipalities play a key role in adaptation to climate change is that they can – within their administrative boundaries, in agreement with local stakeholders, taking into account the interests of the various locally relevant sectors and local actors – create a regulatory environment **enabling them to adapt to climate change**. Accordingly, they play both a coordinating and an integrating role in local adaptation.

Adaptation to climate change **is a process** in which municipalities recognise unfavourable impacts, seek for, and identify, the best possible responses and integrate them in their decision making, planning and operating processes.

Chapter 2 - Natural water retention solutions and climate adaptation

The water-related threats and risks, described in Chapter 1, have long been present in Europe and we have had to take actions to protect ourselves. Applied engineering solutions have been created to respond to issues, however, it might not be possible to apply them in the future in a cost effective way in the extreme circumstances expected to be brought on by climate change. Most of the so-called grey infrastructure facilities in place are based on technology; they take long to be designed and are costly to be implemented, and even the operation and maintenance of many of them cost a lot of money. For **effective adaptation** these engineering solutions need to be supplemented with other, **natural, interventions** or replaced with solutions based on altogether different foundations.

Natural water retention solutions are interventions whose primary purpose is to increase the water storage capacities of soils and wetland habitats. These are, in the majority of cases, **small scale** solutions retaining surface water, such as rivers and streams, or run-off waters after rains, so as to release it slowly and in a controlled way, back into the environment, to even out differences between periods of abundant and short supplies of water. Moreover, they **provide** a lot of **co-benefits**, in terms of erosion control, soil protection, the creation and preservation of natural habitats, microclimate regulation and the creation of recreational possibilities. Their application helps mitigating climate change and adaptation to its impacts. Some examples for natural water retention solutions:

- **Natural water retention solutions alongside watercourses and lakes** – The utilisation of still existing, active landscape elements or former (drained) ones offers lots of opportunities for nature-based water retention.
  - *Storage basins and lakes*
  - *Restoring wetland habitats and floodplains*
  - *Floodplain farming*
  - *Enhancing the naturalness of small watercourses, restoring their bends*
  - *Restoring oxbow lakes, supplying them with water*

- **Natural water retention solutions in forestry –** Forests can retain immense amounts of water. The following is a list of solutions that can be effectively utilised in woodlands:
  - *Forestation of upper river basin areas*
  - *Selection cutting, continuous cover forestry*
  - *Water and sediment retention in small ponds and reservoirs*
  - *Leaky dams of logs and twigs*

- **Water retention in agricultural areas** – much of the area of European countries is made up of arable land. Through increasingly extreme precipitation patterns climate change has its most profound impacts on agriculture.
  - *Planting shelterbelts, hedges*
  - *Adjusting cultivation techniques*
  - *Storing water in drainage canals*
  - *Retaining inland excess water on low-lying arable fields*
  - *Extension and optimised location of pastures, grasslands, hayfields*

- **Water retention in built environments** – One of the key differences between built environments, such as inner areas of towns and villages, and outer areas, lies in the respective ratios of paved surfaces, asphalt roads and pavements, stone-paved areas, buildings and roofs.

In a built environment the so-called heat island effect and inner area inundation tend to constitute the greatest challenge. Possible methods for water retention in a built environment:

- *Water permeable pavements*
- *Unpaved water drainage ditches, canals*
- *Rain gardens*
- *Storm water reservoirs, infiltration pools*
- *Greywater and wastewater management*
- *Utilisation of rainwater around the house*
- *Green roofs*

Chapter 3 – Recommendation for municipalities for the implementation of water retention solutions

This chapter contains descriptions of **exemplary small scale natural water retention solutions** designed and implemented **under the LIFE-MICACC project** in areas belonging to the five municipalities (of Bátya, Püspökszilágy, Ruzsa, Rákócziújfalu, Tiszatarján) as well:

(Photos: Filmever Stúdió)

We also describe the **various steps of the implementation of the natural water retention solutions** as follows:

- *Climate vulnerability assessment, identification of local resources enabling the assessment*

The vulnerability assessment is a useful tool for establishing the climate change-induced vulnerability of a town or village (exposed sectors, frequent incidents in which damage occurs) and for mapping and ranking the available local resources and possible interventions. (Further aid materials for a vulnerability assessment are to be found in "Documents" on the homepage[1].)

- *Design and other technical matters*
- *Financial implications*
- *Matters relating to the obtaining of the water rights establishment permit*
- *Conducting a procurement/public procurement procedure*
- *Matters relating to execution*
- *Obtaining an operating licence*
- *Assessment of the impacts of the implemented solution – monitoring*
- *Achieving sustainable operation*
- *Integrated inclusion of adaptability options in the municipality's strategic planning*

Chapter 4 - Continuous involvement and communication

Addressing, involving and informing those concerned/the stakeholders must be a continuous process during the entire term/period of the given project/development. Local residents are usually interested in what, and for what purpose, is being put in place in their town or village, and how it will affect their lives. Accordingly, and in order to boost their commitment to the project at hand, local residents and stakeholders should, by all means, be kept informed about progress being made.

Project communication in the case of the LIFE-MICACC project took place in the most effective and efficient locally customary way in each of the five villages concerned, from the very beginning. In this chapter we will show how **municipalities participating in the project used their proven local communication channels** (website, social media, local television, radio, newspaper) **to continuously inform and involve local residents**, as a result of which news of the projects reached both local residents and those of nearby towns and villages. Thanks to the efforts made at raising awareness some organised planting trees, others launched drawing competitions; each municipality found ways to inform and involve the local population. They managed to draw residents' attention through the project to climate change and the need for adaptation.

[1] https://vizmegtartomegoldasok.bm.hu/en/documents

1. CLIMATE CHANGE AND POSSIBLE ACTIONS TO BE TAKEN BY MUNICIPALITIES

1.1 Climate change in the Danube River Basin

The annual average temperature has been rising steadily for decades now but the most challenging problems arise not from the average temperature rise of about +3-5 °C but a variety of extreme weather events (droughts, dry spells, forest fires, heat waves, floods, flash floods, inland excess water, frost etc.). It is known from news and we can all experience it in our own communities how weather phenomena and other events reflecting climate change are growing more and more extreme. There have always been floods, flash floods and droughts, but extreme weather conditions have grown significantly more frequent and more devastating during the recent decades. Increasing scarcity of water, uneven distribution of precipitation, aggravating problems of inland excess water and floods show that we must not disregard the changes taking place.

1.2 The most important weather extremes

A) Heat waves

Projections show that air temperature will rise by 1-1.5 C in the Danube Delta, which will lead to an increased frequency of heat waves and hot days, as well as milder winters. Water temperature will rise by an average of 2 C. Projections predict a 0.5m rise in the level of the Black Sea by 2050, while small rivers will carry 5-25% less water, particularly in the summer.[2] All regions of Europe are in for increased frequencies and intensities of extreme heat impacts and heat waves.[3]

Global warming and the changing physical environment will also affect the living environment; new species may appear and proliferate, including pests in agriculture, allergenic weeds posing a health risk, or species spreading diseases, such as tiger mosquito and ticks. The spreading of non-indigenous – invasive – species, pathogens and diseases should also be expected.

B) Water budget: droughts and floods

It is generally agreed that extreme weather events will grow more frequent and more extreme in much of the Danube basin in the future. Since weather extremes will grow more frequent and more intense, the frequency of extreme hydrological events (floods, droughts) is also expected to increase.

Drought, water scarcity: Droughts and low flow rate events as well as instances of water scarcity are expected to become more intensive, longer and more frequent in the Danube river basin. The Carpathian region, particularly the southern parts of Hungary and Romania, as well as the territory of Serbia, Bulgaria and the Danube delta, will likely be facing severe droughts and water shortage stress situations.

Flood: Floods are expected to become more intense in the whole of the Danube river basin in general, particularly in small and hilly river basins. Specific local trends will evolve inside the basin, particularly as regards extreme flood events. Flood intensities and frequencies will probably increase; particularly the number of small and medium flood events will grow, especially in the Alps regions in late winter and spring, triggered by winter snowfall and the shrinking of permanently snow-covered areas.

[2] https://www.icpdr.org/main/publications/preparing-climate-change-danube-delta
[3] https://www.eea.europa.eu/themes/climate-change-adaptation/adaptation-policies/adaptation-policies-in-transnational-regions

Flash flood: Short flood events may increase in frequency. In the case of small river basins flash floods caused by more extreme weather events (intense copious downpours) should be expected to grow more frequent and more intense (e.g. in the Carpathian mountains, or in the sub-basin level, in the catchment areas of the rivers Sava and Tisza.)[4]

C) Expected ecological impacts

Rising air and water temperatures are causing major long term changes in precipitation, the availability of water and in water quality as well as the increasing intensity and frequency of extreme events (floods, low flow rates, droughts), affecting ecosystems and biodiversity in the Danube river basin. This is often referred to as one of the most severe negative impacts of climate change. Habitats and ecosystems are particularly likely to dry out in the south-eastern region of the Danube river basin and in the Hungarian Great Plain.[5]

D) Other weather extremes

Other unusual extreme weather events should also be expected in addition to those referred to above:

- more frequent and stronger windstorms;
- more frequent and more intense lightning (and thunder) activity;
- season shifts;
- damage caused by ice and frost earlier than expected or in unusual periods;
- unusually mild winters.

1.3 Climate change impacts on towns and villages

The above climate changes will impact **towns and villages with different geographical and environmental conditions and factors** in different ways.

Towns and villages in plains, along great rivers

Towns and villages in the plains which used to be large rivers' floodplains (like those in Hungary), are simultaneously threatened by inland excess water, floods and droughts. Springs with inland excess water or floods are often followed by extremely dry summers and both too much water (floods, inland excess water) and too little water (water scarcity, drought) cause problems. A large part of the Hungarian Great Plain is exposed to floods, inland excess water as well as drought.

Towns and villages in hilly areas

The main source of danger facing towns and villages in hilly areas comes from flash floods. These are brief flood waves following heavy rains passing down in a matter of hours, unlike the floods of great rivers, yet causing just as severe damage to the natural and the built environment.

1.4 Adaptation: preparing for the unknown

[4] „Update of the ICPDR Strategy on Adaptation to Climate Change" (Update of the ICPDR strategy on climate change adaptation, 11 December 2018., p. 22 (available only in English)

[5] "Update of the ICPDR Strategy on Adaptation to Climate Change" p. 24

The climate change process can no longer be stopped altogether; however, its negative impacts can be mitigated by adaptation. **Adaptation is a process** whereby unfavourable impacts are recognised and integrated in our decision making, planning and operating processes, identifying optimum responses to the above impacts. Rather than concentrating on a single point, group or area this approach enables assessment of all potential impacts of climate change whenever decisions or choices have to be made. To mitigate adverse impacts municipalities may increase capacities, contribute to awareness raising, amend strategies and regulations, introduce taxes or launch specific projects (e.g. for water retention).

Example for good adaptation: use of passive techniques (e.g. by adequate heat insulation and shading of buildings), together with air conditioning powered by electricity generated from renewable energy sources (e.g. solar or wind).

Example for bad adaptation: unrestrained use of air conditioners in the way of protection from heat waves (relying, for instance, on power generated by a power plant), for their energy consumption entails the emission of green house gases, leading in turn, to intensified warming in the long

This however, is by far not as easy as it may sound. Some erroneous adaptation solutions, for instance, may solve a problem at a given point but only to a certain extent and not effectively enough: either by shifting the problem to another geographical location where it will be somebody else's problem, or by putting off the solving of the problem so that the same challenge has to be tackled by the next generation; or even by creating a completely new problem for another sector. Such solutions are referred to as bad adaptation. The following two text boxes show one adequate and one botched way of protecting a family house against heat waves.

1.5 Municipalities' special role in adaptation

Although climate change is a global challenge affecting the whole world, it is crucial that we get prepared for, and adapt to, its impacts at as many levels as possible, i.e. at the levels of continents, regions, countries, counties, towns and villages as well as individuals. All decisions, directives and resolutions adopted at a global level and those of the European Union, along with regional collaborations, national strategies and plans are aimed at enabling the identification of climate policy priorities on the basis of comprehensive shared goals and orientations. The importance of such documents is indisputable. It should also be recognised however, that – in view of the principle of subsidiarity among other considerations – the local level is the most suitable level for implementing practical interventions and for adaptation. The local (municipal, territorial) level in Hungary is made up of 3177 municipalities[6]

Municipalities **are operating in a single regulatory environment and cover the whole territory and population of Hungary**; municipalities are present locally and they communicate directly and regularly with citizens. Municipalities have the most profound knowledge of the climate and exposures of their respective towns and villages, they experience the negative impacts of climate change, therefore they are adequately motivated towards improving the situation. Municipalities are aware of their communities' conditions and situations (natural values, neglected areas, areas that can be used in future projects, human resources, available funds etc.). Municipalities know residents and local stakeholders best, they can communicate with, and activate, them, whereby they can contribute to

[6] In this guide we present our experiences on the basis of the municipality system in place in Hungary. This "self-governance/municipal/local" level is also present in each of Hungary's neighbouring countries so it is worth applying the content of this guide to the same level in place in those countries.

shaping, improving and developing the local community. Moreover, municipalities develop local plans and strategies as decision makers; they can integrate the adaptation attitude in the local decision making process. In other words, municipalities play a key role in in climate change adaptation and in involving residents, just like in a number of other functions. For this very reason it is important that adaptation be coordinated locally, with the involvement of all stakeholders.

A MUNICIPALITY

- knows its community and its conditions
- knows the climate-related challenges facing the town or village
- know the local stakeholders
- develops local strategies and plans

➔ **is a key actor in local adaptation**

The reason municipalities play a key role in adaptation to climate change is that they are responsible for the proper functioning of a given territorial unit and that – within their administrative boundaries, in agreement with local stakeholders, taking into account the interests of the various locally relevant sectors and local actors – they create a regulatory environment **enabling them to adapt to climate change**.

The leaders of the municipality may prescribe, in the **regulatory instruments**, such as the town's or village's planning instruments, the possible type(s) of land use for endangered areas and regulate local construction requirements as well. For example, they do not designate new sites for construction in potentially waterlogged sites, they designate adequately wide public areas where trees can be planted for shading, or they prohibit the construction of cellars in municipal areas exposed to potential inundation. Such regulatory measures can help avoid damage to infrastructure, improve the quality of life in the community and make the place safer for the operation of businesses as well. Another important aspect is the integration of the adaptation attitude in local plans and strategies.

The main purpose of this Adaptation Guide is not to assign additional tasks to municipalities; much rather, we wish to integrate the above attitude and approach and enable its extensive use in municipalities' day-to-day work as regards adaptation to climate change. Relying on local knowledge and using locally available resources they can implement cost effective solutions creating healthier and more favourable conditions for life, contributing to making the community more adaptable and to creating a more liveable municipal environment that is more responsive to climate change impacts.

The negative changes discussed in subsection 1.1 are reflected most saliently, in a form that is most perceptible in our day-to-day lives, by their impacts on waters. Changes in water take place as a combined effect of changes in multiple climate factors. A variety of actions may and can be taken to counter negative impacts. This Guide is intended to contribute to helping Hungarian towns and villages and those of neighbouring countries to adapt to negative impacts of climate change by presenting complex semi natural solutions and the benefits of their application, and by sharing information and experiences required for their implementation.

CHAPTER 2 - NATURAL WATER RETENTION SOLUTIONS AND CLIMATE ADAPTATION

In Chapter 1 we discussed how the most clearly perceptible effects of climate change will include changes in hydrological conditions, besides temperature variations. We are bound to be faced with more and more extreme water-related climatic risks and hazards such as droughts, floods, heavy rains, waterlogged fields. These may cause massive problems for any municipality, threatening municipal property and assets, the daily lives of residents and the reliable operation of local businesses. Increasingly heavy damage may be expected to be caused by water both within and outside the administrative boundaries of municipalities. At times there is too much water (flood, flash flood, inland excess water in waterlogged fields), while at other times there is a shortage of water (drought), for which the best solution is **evening out the differences between wet and dry periods, as much as possible**.

One **often** encountered **example** is that raising flood protection embankments to prevent the flooding of areas is extremely costly over a given height, so this solution alone is not sufficient in preparation for extreme floods.

2.1 Green infrastructure and grey infrastructure

The above climate threats and weather extremes have already occurred before and we have had to provide protection against them. Engineering solutions for each such problem have been applied so far; however, it might not be possible to apply them in the future in a cost effective way in the extreme circumstances expected to be brought on by climate change. Most of the so-called grey infrastructure facilities are based on technology[7]; they take long to be designed and are costly to be implemented, and even the operation and maintenance of many of them cost a lot of money.

For effective protection these engineering solutions **need to be supplemented with new interventions** or replaced with solutions based on altogether different foundations. In the search for new solutions an increasing number of experts and other professionals in water management, urban development and urban management are shifting focus to so-called **natural water retention solutions**. These are solutions whose primary purpose is to increase the water storage capacities of soils and wetland habitats. These are, in the majority of cases, **small scale** solutions retaining surface water, such as rivers and streams, or run-off waters after rains, so as to release it slowly and in a controlled way, back into the environment, to even out differences between periods of abundant and short supplies of water. This practice contributes to the rehabilitation of the water cycle of small regions, simultaneously with water retention whereby they can ultimately contribute to sustainable water management. Their key advantage however, lies in providing a variety of **co-benefits** besides this function; in contrast to, for example, the grey infrastructure solutions which tend to perform one or another specific function efficiently and effectively without providing any co-benefit, indeed, in some cases creating new tasks to be tackled by other sectors.

[7] Technology-based solutions: usually, infrastructure elements designed and put in place by man and based on technology made not of natural materials but mostly of steel and concrete, which do not adequately factor in the given landscape and natural features and conditions.

What are natural water retention solutions?

They are multifunctional solutions protecting water resources and contributing to resolving other water-related issues based on automatically functioning natural processes through restoring and maintaining ecosystems. The purpose of their use is to enhance the water storage capacity of habitats, soil and subsurface aquifers while improving the state and condition of waters and water-dependent ecosystems. They expand the green infrastructure network, improve the status of waters in terms of quantitative and qualitative parameters, reduce vulnerability to droughts, heat waves as well as floods through natural processes, by strengthening the so-called ecosystem-services. Moreover, they provide a lot of co-benefits, in terms of erosion control, soil protection, the creation and preservation of natural habitats, microclimate regulation and the creation of recreational possibilities. Their application helps mitigating climate change and adaptation to its impacts.[8]

2.2 Natural water retention solutions

The following attributes are characteristic of such solutions:

- In general, they are applied on the basis of the "many a mickle makes a muckle" principle.
- They provide multiple co-benefits: they generate benefits in nature conservation, the economy, water protection and recreation, through bolstering ecosystem-services.
- Consequently, they contribute to the attainment of many of the EU's and Hungary's strategic goals.
- They make their impacts through facilitating natural processes or through applying semi natural solutions, even if they are not fully natural.
- These are automatic natural systems so they are much less expensive to maintain and operate than are grey infrastructure elements, i.e. they are cost effective.
- The intended impact is generated usually through the combined application of multiple solutions, where the challenge lies in finding the right combination of solutions.

These solutions are not new in themselves; they have long been used extensively and some of them may have had different names. These include, for example, sustainable rainwater management systems, shelterbelts, wetland habitat reconstruction and storm water reservoirs. What's new is the recognition the extensive **carefully planned application** of such solutions **at multiple sites is capable of making a significantly greater impacts, at regional or even national level**, enabling even the substitution or supplementation of costly grey infrastructure.

Why is it worth working with natural water retention solutions?

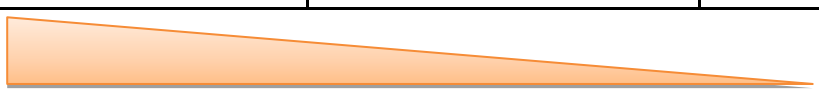
Natural water retention solutions offer a variety of benefits therefore experts of different sectors may be motivated by different considerations in applying them:

- Very low maintenance and operation input requirement, cost effectiveness exceeding that of grey infrastructure.
- One solution is suitable for tackling multiple problems efficiently and effectively, yielding more benefits for the various actors and sectors.
- They contribute to the attainment of multiple EU and domestic strategic goals simultaneously, so they can be financed from multiple sources (funds).
- These solutions cannot fail economically – "no-regret measures" – generating co-benefits even if the expected negative impacts of the climate change fall short of the predicted extent.

[8] Based on European Commission, 2014 – EU policy document on Natural Water Retention Measures

2.3 Comparison of green and grey infrastructure solutions

The following is an example to illustrate the difference between green infrastructure solutions based on natural processes and grey infrastructure solutions based on technology.

Possibilities for adaptation to drought and inland excess water	**Water retention in grabens**  Photo: Csaba Vaszkó, WWF HU	**Open canals with dual functions**  Photo: pixabay.com	**Drain piping and pipeline irrigation**  Photo: pixabay.com
Green or grey infrastructure?	Natural	Natural and artificial elements	Fully technology based
Implementation cost			
Operation and maintenance cost	Mowing or grazing. Water retention is free of charge.	Mowing, dredging of canals; operation of pumps; water extraction contribution.	Operation of pumps; payment of water extraction contribution.
			
Area required			
Co-benefits	Groundwater replenishment Water retention Microclimate regulation Water quality improvement Habitat creation Recreation Livestock keeping	Microclimate regulation	–
			

The above example shows that grey infrastructure solutions usually involve major earthwork, costly development projects and technology-based solutions. Their operation and maintenance are expensive and require expertise, their planning and preparation take a long time and they can usually fulfil only a single function without providing any co-benefits. The advantage of nature-based solutions lies in their suitability for managing multiple problems at a time. Their disadvantage is the need for a larger area because some piece of land that is not being used for any particular purpose, or field of low

fertility has to be devoted to use for water management or some other use tolerating periodical inundation (e.g. pastures, hayfields, orchards).

Underground water retention
As a consequence of – primarily the indirect – climate change impacts (including a growing demand for water) the water resources stored in underground aquifers are also more and more at risk. Therefore in addition to surface water retention increasing efforts are now being made to facilitate the recharging of underground aquifers to enable sustainable use of groundwaters. This is the aim of a the application of a new approach, that is, the use of natural infrastructure based on groundwaters[9], including one of its variants: targeted groundwater recharge. The latter is a technique whereby aquifers are recharged in a targeted way – with the aim of generating environmental benefits (e.g. raising the groundwater table) or for subsequent water extraction (for irrigation or drinking water supply) – through facilitating the infiltration of surface water or by capturing and collecting water. This method involves a combination of green and grey infrastructure elements since an underground aquifer is, in itself, to be regarded as "green" (blue) infrastructure, while its operation requires various structures (e.g. infiltration wells and basins, underground embankment, production wells). Such solutions make it possible to improve the quality status of underground water bodies. The quality of the water intended to be infiltrated is particularly important; contamination must not reach underground resources.

2.4 Selection, design and implementation of natural water retention solutions

The a wide variety of processes may be involved in the design and implementation of natural water retention solutions: the complete process(es), together with all relevant details cannot be discussed in this guide. The following considerations and aspects should, however be assessed by all means, during the selection, design and implementation of the appropriate solutions:

A) What is the primary objective of the solution? First of all, the problem for which a solution is needed is to be identified and specified. What is the primary goal of natural water retention? These depend on the conditions and resources of the given town or village and the local vulnerability to climate change. Such goals may be to mitigate flash floods; to prevent water from carrying off soil, and to prevent mud flooding; to mitigate the impacts of dry spells and droughts; to provide protection against heat waves; to develop urban green areas etc.

B) Stakeholder involvement: what are the most important co-benefits for the local community and the stakeholders? The key advantage lying in natural water retention solutions is that they form a system that is not focused on attaining a single objective but tend to generate a variety of benefits for multiple sectors – this however, varies from solution to solution. Accordingly, consultations with the stakeholders are indispensable, to identify **the co-benefits most in demand in the community.** The municipality's leadership should consult representatives of the following sectors:

- water management;
- urban management;
- forestry;
- agriculture – local farmers;
- nature conservation – national park, local nature conservation association;
- representatives, opinion leaders of the local community, local civil society organisations.

[9] Based on Groundwater Solutions Initiative for Policy and Practice; https://gripp.iwmi.org/.

C) Selection of the appropriate combination of solutions: the desired result can usually be attained by applying a combination of multiple solutions. Natural water retention solutions often need to be combined with grey infrastructure solutions. It is at this point where a cost-benefit analysis is carried out in most design phases to find the most efficient and effective solutions. It should be noted that it is difficult or impossible to establish the value of the co-benefits and ecosystem services of natural water retention solutions in terms of money; however, these should also be taken into account in the analyses. Another consideration to be taken into account is that nature-based solutions, if adequately designed and put in place, typically help achieve the goal without causing damage to other sectors.

D) Feasibility: such solutions should be used in which **already existing landscape elements** (surface depressions, gullies, excavation pits, existing canal network, former oxbow lakes, grasslands, woodlands) **can be used**, so that the solutions can be put in place and maintained together with, rather than against, existing natural and landscape features.

2.5 Some examples for natural water retention solutions:

A wide variety of natural water retention solutions exist. A collection of such solutions, categorised by areas of applications and co-benefits, illustrated through existing good examples, can be found on the European Union's website **www.nwrm.eu**, prepared with input from Hungary as well as other countries.

Scientists of the Oxford University processed, organised and rendered searchable, results of nearly 300 scientific publications, on the "Nature-Based Solutions Initiative" page[10]. The database processes and presents natural solutions that are suitable for mitigating climate change impacts. The results can be searched by criteria such as type of measure, climate adaptation effects as well as the social, economic and ecological benefits attained. For the time being the website is only available in English.

Showing all of the existing examples would exceed the limits of this publication. The solutions we consider to be widely usable in Hungary and other countries along the River Danube and in Central and Eastern Europe in climate change adaptation are discussed below from the aspects of their respective areas of use, based on our experience and knowledge gained from the implementation of the LIFE-MICACC project.

We also recommend the LIFE-MICACC application, also created under the project, to provide community-based information on natural water retention solutions and make it possible for stakeholders to learn, build up knowledge and share good practices. The English-language application is downloadable free of charge from Google Store as well as from Apple iStore.

2.6 Natural water retention solutions along watercourses and lakes

Thanks to its geographical location in a basin Hungary is very rich in both surface waters and groundwaters. For instance, the amount of water carried through the territory of Hungary by its rivers each year is about twice as much as its annual precipitation. While this amount of water spread out in the floodplains of rivers and streams centuries ago, about a quarter of the territory of today's Hungary was periodically inundated, forming various types of wetland habitats. Although much of those wetland habitats disappeared in the wake of great river regulation projects, the landscape elements

[10] https://www.naturebasedsolutionsevidence.info/

enabling water retention, such as floodways, dried-out riverbeds or lake beds, grabens, cut-off oxbow lakes, former lakes and bogs or their residues are still present. Relying on geographical features the utilisation of still existing, active landscape elements or former (drained) ones offers lots of opportunities for nature-based water retention.

2.6.1 Storage basins and lakes

Storage basins and lakes can be created in both plain and hilly areas. A lake can function as a wetland habitat all year round and during periods of abundant precipitation they are suitable for storing extra amounts of water. Such lakes are very easy to create near towns and villages in the Great Plain in the sites of abandoned clay quarries or excavation pits (discussed in more detail in subsection 3.1.1 on the pilot site near Bátya). Storage basins, by contrast, only hold water periodically. One advantage of periodically flooded basins is that in addition to being used for water management they can make excellent pastures or hayfield, because areas of ample water supply produce a lot more grass and can sustain significantly more grazing animals and during most of the year grazing is not prevented by the periodic inundation. Such storage basins can be conveniently created along small streams where they can function as storm water reservoirs, as well as in the active floodplains of larger rivers. In creating such water retention solutions care must be taken to ensure that the lake bed or storage basin is not as deep as to reach the groundwater table because in that case the lake's open water surface lowers the groundwater table through evaporation, which would have negative impacts.

2.6.2 Restoring wetland habitats and floodplains

Some 87% of the former wetland habitats disappeared and most of them became dry areas, in Hungary in the wake of the regulation of riverbeds and the construction of drainage canals. Such former floodplains, marshes, fens and other wet meadows are landscape elements still suitable for water retention wherever water actually accumulates during certain periods.

Floodplain: an area along a river that may be flooded when the flood protection embankment fails.

Floodway: the area between the edge of the riverbank and the flood protection embankment, or high riverbank (that part of the riverbank which is higher than the highest flood level).

Protected floodplain: part of the floodplain, protected by flood protection embankments from being inundated. So-called former floodplain[11].

1 – The municipality of the village of Tiszatarján has created a complex landscape use model in the floodway of the River Tisza. (Photo: Csaba Vaszkó)

There are three methods for restoring floodplains: extending the floodway and improving its naturalness status and, on the protected side, controlled connection of grabens in the former floodplain with the river. Extending the floodway is a costlier intervention, as it necessitates relocation of the flood protection embankments. One good example for this is the relocation of the embankments of Lake Bivaly. Enhancing the naturalness of, and removing invasive plant species from, existing floodplains is a less expensive solution; it only requires changing the land use category. One good example for this is the pilot site at Tiszatarján (Chapter 3). Former floodplains on the protected side can also be

[11] https://www.kotivizig.hu/index.php?option=com_content&view=article&id=826&Itemid=137 (available only in Hungarian)

rehabilitated by making it possible to regularly channel off water during high discharge periods in a controlled way, without having to relocate the embankments. Floodwater can thus be distributed in a controlled way, without causing damage, in a suitable lower-lying area, thereby enabling the former floodplain flora and fauna to return and methods of floodplain farming to be reintroduced. One good example for the a restored wetland habitat's supply with water flood waves is Lake Rétközi, a structure functioning primarily as an inland excess water reservoir but during periods of water scarcity it is also suitable for retaining floodwater from River Tisza and it can also be supplied with pumped water.

2.6.3 Floodplain farming

Floodplain farming is a system of conventional agricultural practices that used to make it possible to adapt farming in the original floodplains of great rivers to floods and periodic water cover. The essence is that floodwater is allowed to flow out onto the floodplain in a controlled way where different farming practices are used in the areas of different altitudes which are thus inundated at different frequencies. Fishing was practised in the deepest, most frequently flooded areas; forests or floodplain orchards, or pastures were cultivated in other frequently flooded areas. Arable lands and villages were only to be found in the highest lying areas. Floodplain farming adapt agricultural practices to the landscape instead of adjusting the land to farming, which therefore does not require irrigation or drainage of inland excess water. At the same time, it creates a mosaic of landscape elements which is not suitable for monoculture farming on large fields.

At the village of **Nagykörű** in the North Great Plain more than 100 excavation pits were connected by canals in a floodway area in a LIFE project, enabling the retention and controlled discharge of floodwaters. The resulting wetland habitat system functions as a spawning area and fish nursery so it is suitable for conventional fish farming. Further information in Hungarian: www.tiszalife.hu.

2.6.4 Enhancing the naturalness of small watercourses, restoring their bends

The beds of large number of small watercourses have been regulated to enable quick discharge of water, resulting in straight stream and river beds of a trapeze cross sections. The areas so dried out were subsequently built up or used for agricultural production. Watercourse regulation however, some negative side effects, in that the quick discharge of water increases the risk of floods on lower sections of the streams concerned and aggravates droughts in areas along the regulated sections. As a consequence of various local circumstances some areas could not even be properly drained therefore inland excess water appears from time to time in place of, and around, the former stream bed because it is still these areas where groundwater wells up when its level rises. The stream bed loses its role as a habitat and as a landscape element, while its technical maintenance is a costly operation year after year. Along section where there is a land strip along the watercourse available for this purpose all of these issues can be remedied simultaneously by increasing the stream's naturalness and restoring its original bends. Such interventions often require a significant area but they are often highly welcomed by the local community, even in an urban environment.

2 – In the Czech village of Hostovice the risk of flood was reduced by restoring the bends of the stream flowing through the village and by flattening its floodplain, creating an attractive park in place of a former canal. (Photo: Viktor Mátyás Farkas, WWF HU)

2.6.5 Restoring oxbow lakes, supplying them with water

Oxbow lakes, that is, cut-off former river sections can be formed by natural processes as well but in Hungary a huge number of artificial oxbow lakes were created, which then ended up on the protected side of the embankments.

3 – An oxbow lake restored under the Ó-Dráva LIFE project. (Photo: WWF HU.) For further information visit: **http://www.olddrava.com/en**

Without adequate maintenance these fill up with silt, and disappear over time, despite the fact that they would be an excellent means for water retention. One important intervention towards their maintenance is through restoring their water supply, because flowing water improves their water quality and slows down the process of silting up.

Restoring an oxbow lake may require removal of the mud, which is a highly expensive intervention.

2.7 Natural water retention solutions in forestry

Forests can retain immense amounts of water. Its effectiveness can be further increased by small scale technical solutions and by making changes to landscape use and forestry practices. Much of Hungary's remaining forests are to be found on hilly regions and the country's mountains, which are crucially important areas for water management. Of course water retention is just as important in forests in plain areas but their impacts are more relevant locally. The following is a list of solutions that can be effectively utilised in woodlands:

2.7.1 Forestation of upper river basin areas

Upper river basin areas are typically hilly and mountainous areas where creeks and streams originate. Given their conditions, **surface watercourses and groundwater are supplied primarily by precipitation** in such areas, in contrast to lower river basin areas to which larger amounts of water flow through streams as well as with groundwater from the higher lying areas.

4 – Upper catchment area of Stream Szilágyi. Much of the stream's catchment area is made up of arable fields where intensive cropping is taking place; during periods without vegetation cover it is incapable of retaining water from heavy rains or slowing down erosion. Up to 10-12 mm of the top soil can be washed away from arable fields in hilly areas; from meadows and pastures only about 0.04-0.07 mm, while from forests even less soil is carried off by water. Forestation of upper river basin areas – or turning them into grasslands – is therefore a long term solution, reducing the risks of flash floods and mud flooding in the entire lower catchment area. (Photo: Viktor Mátyás Farkas, WWF HU)

In this way, retaining water and slowing down its flow in upper catchment areas **helps evening out the flow regimes**, i.e. dampening peek floods and extremely low discharge rates, in both the hilly areas and **in areas lower down.** Many hillside areas are, however, used for field crop production and arable fields have an extremely low capacity to retain water or slow down the flow (run-off) of water, and as a consequence of the heavy soil erosion by water intensive cropping on large fields in these areas is not sustainable. Forests, preferably of indigenous tree species, should be planted on such steep hillsides, which is, in terms of direct financial benefits, less lucrative in the short term but a different conclusion may be reached if the co-benefits (flood protection, reduced erosion) are also taken into account.

2.7.2 Selection cutting, continuous cover forestry

The so-called continuous cover forestry technique is spreading across Hungary, although it is still only practised on a relatively small proportion of the total woodland area (it was 1.1% in 2017). Its advantage relative to contrast to rotation forest management – ultimately ending in clear-cutting, that is, temporary removal of the forest cover – is that the forest as a functional ecosystem never fully disappears and is continuously capable of maintaining natural forests' typical ecosystem-services. Such services include, among other things, the maintenance of a forest climate and effective retention, and slow discharge, of rainwater.

By contrast, rotation forest management completely removes the forest for a while: after the so-called clear cut the forest cannot, for years, fulfil its natural role: run-off increases, together with soil erosion, the multi-layered vegetation disappears. The removal of the trees destroys most of the forest habitats and the microclimate regulation function also disappears.

2.7.3 Water and sediment retention in small ponds and reservoirs

Forests' varied topographical conditions and the possibility of planting tree species tolerating inundation (e.g. alder) offer excellent opportunities for creating small water reservoirs or wetland areas in areas taken care of by forestry companies.

These are capable of stopping the drying out of forests, they even out flow regimes and regulate microclimates. The Polish state forestry company has, for decades, been creating small water reservoirs and other water retention solutions in its areas[12].

5 – Water retention pond and structure in an area managed by the forestry company. They are retaining water in order to prevent the aridification of their forests. (Photo: V. Mátyás Farkas, WWF HU) For further information visit: www.kaszo-life.eu/

[12] The report on the study tour to Poland is available on the website here: https://vizmegtartomegoldasok.bm.hu/storage/dokumentumok/Study%20trip%20to%20Poland_report.pdf (a projekt honlapján angolul és magyarul elérhető)

2.7.4 Leaky dams of logs and twigs

Leaky dams of logs or twigs, made of locally grown wood, are used in upper catchment areas of periodic or permanent small creeks and streams for controlling discharge rates.

Logs do not obstruct the movement of fish because the creek can always flow through underneath the logs during periods of low or medium flow but after rains the log dam slows down flow rate and creates a temporary impounded "reservoir".

6 – Leaky log dam in the forest above Pickering, England. (Photo: Klára Kerpely, WWF HU)

These structures should be put in place in upper catchment areas where the given creek has an extensive flood plain on which a lot of water can be retained without the risk of inundating infrastructure (roads, buildings, bridges). They can be used for stopping ditches and gullies caused by erosion as well as preventing continued deepening of their beds. Slowing the flow and retaining as much as possible of the material carried by the water reduces flood peaks in the lower catchment area where overflow could threaten infrastructure. A single log dam can only create a small storage capacity (up to a few hundreds or thousands of m^3) so a series of such dams should be constructed on a creek or stream. Preparing a flow model may help determine their ideal locations because dams placed in wrong places may even increase the risk of floods. For more detail see Püspökszilágy pilot site (Chapter 3.1.2.) and the summary of the study tour in England.[13]

2.8 Water retention in agricultural areas

A total of 57% of Hungary's territory is made up of agricultural lands. Through increasingly extreme precipitation patterns climate change has its most profound impacts on agriculture. Utilising the potentials lying in water retention is an important means of adaptation to climate change in agricultural lands in both plain and hilly areas. In plain areas water retention solutions play a major role as a protective measure against droughts and inland excess water, while in hilly areas they help mitigate soil erosion and flash floods.

7 – Shelterbelt between two arable fields. (Photo: Klára Kerpely, WWF HU)

[13] A summary of the nature-based flood defence system in Pickering, England: https://vizmegtartomegoldasok.bm.hu/en/news/the_life-micaccs_team_traveled_to_england (available in English and Hungarian on the project website)

2.8.1 Planting shelterbelts, hedges

Shelterbelts are thin strips of trees and shrubs between large agricultural fields. They provide a great variety of ecosystem-services that cannot be expressed in terms of money.

They mitigate erosion by wind and water; they protect roads from blizzards, mudflows and strong side-winds; they shade watercourses thereby reducing surface evaporation; and they provide a habitat for birds, pollinators and other useful insects that help controlling agricultural pests. In areas of large-scale mechanised farming these provide the only shelter for wildlife. Shelterbelts planted parallel to contour lines slow the flow of water down slopes.

2.8.2 Adjusting cultivation techniques

A wide variety of agricultural practices are suitable for increasing the water retaining capacity of an agricultural field, reducing erosion and deflation (which is by far most dramatic in fields with no vegetation) **without changing the type of land use**. In this regard however, emphasis should be laid on such practices' long term co-benefits which will be enjoyed by the farmers themselves too: these include preservation of the soil's organic matter and nutrient content in the long term, mitigation of the risk of drought and reduction of erosion.

Contour tillage in strips is a method of growing different crops in strips on a hillside in order to make sure that the hillside is never entirely without vegetation cover. The different crops of different plant density, in different growth phases, can retain different fractions of the soil being carried off. Following the strips in soil cultivation and harvesting is becoming more and more easy thanks to the ever wider adoption of precision farming technologies (e.g. robot steering).

Ploughing loosens the soil, compromising its health and causing a decrease in its humus content as well as its erosion. The essence of **non-inversion tillage** is that ploughing is made redundant by the use of various seed drills and varying crops, thereby helping the preservation of the high quality, and the humus content, of soils in the long term and improving soils' water management characteristics. Finally, **soil protection with cover crops** involves the sowing the seeds of so-called cover crops in late summer or in the autumn in fields that would be too exposed without such vegetation to erosion by wind and water during the winter. Cover crops increase the soil's organic matter and nitrogen content, and they also enrich the soil's structure.

2.8.3 Storing water in drainage canals

Hungary has one of the most extensive drainage canal systems in Europe: the 42,000 km canal network covers an total cultivated area of 45,000 km^2. Although the main purpose of the canals is to remove inland excess water in years of too much water, they drain off water reserves that accumulate during winter months in all other years as well; indeed, they drain groundwater even in years of drought. The same canals can also be used for water retention in many cases without the construction of new infrastructure, by simply altering the operating regime of the locks or by installing simple water retaining structures (locks, inhibitors).

8 – A section of a canal transformed and managed for water retention in the region called Turjánvidék. (Photo: Annamária Csóka, http://turjanvidek.hu/)

The representatives of the locally competent water management directorate should be consulted about the new operating regime aimed at storing water in canals even where the structures and canal sections are owned and managed by the local authority; the construction of new locks requires authorisation (water permit) from the water management authority. For more detail see the description of the pilot site at Ruzsa (subsection 3.1.3).

2.8.4 Retaining inland excess water on low-lying arable fields

Regular accumulation of inland excess water is a major problem in a substantial part of agricultural lands in Hungary. Of those lands the fields that are in the worst condition should be turned into inland excess water storage reservoirs or used for purposes – **as grasslands, forests, fish ponds or reed beds** – that are compatible with permanent or frequent inundation. Water from nearby fields of better conditions can be collected and stored in these areas. This then alleviates the load on the inland excess water drainage systems, reduces the costs of protection against inland excess water as well as the costs of the operation of pumps, moreover, the risk of damage by drought in the vicinity of the resulting wetland habitat will also be lower because soil moisture will be maintained at a higher level through the slow infiltration of the water even during the dry months. Such "water management areas" should be adapted and adjusted to the landscape features, following the routes of grabens and former riverbeds. Once an extensive mosaic of such small water retention solutions is created on a large scale, in a whole region, their system will contribute to the small water cycle through evaporation to such an extent that will be reflected by local precipitation forming. For details, see the description of the pilot site at Rákócziújfalu (subsection 3.1.4).

2.8.5 Extension and optimised location of pastures, grasslands, hayfields

Grasslands require relatively little water to thrive but they are highly tolerant of inundation. Moreover, they reduce evaporation, preserve soil moisture, effectively reduce soil erosion and fix soil washed off from higher lying areas and take up organic matter from water loaded with nutrients from higher lying agricultural land where manure or fertilisers have been used. Moreover, they produce feed for livestock. The ratio of grasslands is gradually decreasing in Hungary: in 2018 it was as low as 8.6%. Increasing the area of permanent grasslands may greatly contribute to climate adaptation, particularly where their distribution in the landscape is well-planned. Pastures should be formed on hillsides in strips or patches following the contour lines while on plains they should be located around wetland habitats with fluctuating water levels, on floodplains along rivers and creeks, in areas prone to salinisation or in former riverbeds now frequently under inland excess water.

2.9 Water retention in built environments

One of the key differences between built environments, such as inner areas of towns and villages, and outer areas, lies in the respective ratios of paved surfaces, asphalt roads and pavements, stone-paved areas, buildings and roofs. These are causing increasing risks with the progress of climate change. One is gradually intensifying urban **heat island effect**.

A heat island comes about where the darker paved surfaces, concrete structures and buildings in densely built-up areas, as well as the ambient air, become extremely hot in the summer, raising the local temperature by multiple degrees centigrade in comparison with the temperature in nearby rural areas.

Another risk is the **inundation of areas in towns and villages** in the wake of heavy rains. This is because water runs off paved surfaces very quickly without infiltration or deceleration, overloading

the rainwater drainage systems. Increasing the ratios of green and "blue" areas is a good solution for both the heat island effect and the inundation of inner areas by slowing down the flow of water, contributing to infiltration and cooling the environment by evaporation.

2.9.1 Water permeable pavements

A water permeable pavement is a solid pavement allowing rain falling on, or water flowing onto, it to pass through and infiltrate into the soil, thereby reducing or completely eliminating run-off. There are porous water permeable pavements where water can leak through the entire paved surface, and there are non-continuous pavements where part of the water can seep through the gaps between the pavement elements/blocks (e.g. paving stones, lawn grid). Water permeable pavements are to be found most typically on the surfaces of parking lots, roads and sidewalks and driveways/carports.

9 – Water permeable pavement. (Photo: Klára Kerpely, WWF HU)

2.9.2 Unpaved water drainage ditches, canals

Unpaved – grass-covered – water drainage ditches are to be found in many towns and villages in Hungary. One of the advantage of these structures is that during heavy downpours then can channel the run-off from the road surface to the receiving water body, while allowing the water from lighter rains infiltrate the soil on the spot, improving, for instance the chances of survival for trees in public areas. In towns and villages on steeper sloping hillside areas where the kinetic energy of the run-off is higher, ditches need to be paved in some places to prevent erosion and damage. However, there is less reason for paving the drainage ditches in towns and villages in plain areas, where the water flows slowly.

2.9.3. Rain gardens

A rain garden is a natural or artificial depression in which hydrophilic vegetation has been planted, where run-off from paved surfaces can be collected, stored and gradually drained. Soil allowing water to seep through should be used in such areas or a gravel bed is to be created underneath the rain garden to facilitate its function. Rain gardens can be created in public areas as well as on private land; their size should be adjusted to the size of the paved areas from which run-off is to be collected. Rain gardens are aesthetically valuable and they are suitable habitats for butterflies and other pollinators, they need no maintenance, they filter water, increase biodiversity and can be created any time even in already established green areas, at low costs.

10 – Rain gardens can be aesthetic elements of parks, green surfaces and front yards. (Photo: Klára Kerpely, WWF HU)

2.9.4 Storm water reservoirs, infiltration pools

Where the ratio of paved surfaces is high, even a combination of rain gardens, drainage ditches and rainwater management on building lots will not be sufficient to keep the rainwater in place, a substantial amount of water may start flowing off the area. This may overload the drainage system

and there may be a need for structures where water can accumulate and be stored temporarily to prevent inundation. Storm water reservoirs, in place in many towns and villages, are one example of such structures, but **multifunctional green areas** can also be created for this purpose. During much of the year they can function as, for instance, football fields, or other green surfaces, but when necessary they can be also used temporarily for storing water and letting it infiltrate the ground.

11 – Storm water reservoir suitable for temporary inundation, also functioning as a green surface. (Source: susdrain.org)

2.9.5 Greywater and wastewater management

In some towns and villages problems arise from the scarcity of water and heat waves, rather than the abundance of water. Every last drop of water is precious in such communities, worth retaining and taking care of.

The technological water released by from drinking water treatment plants (decant water) as well as the purified wastewater usually discharged by wastewater treatment plants into natural receiving water bodies can be retained and desiccated in semi natural reservoirs. Water retained in semi natural wetland habitats regulate the local micro climate and keeps the community's environment cooler through evaporation. The water so reserved supplies groundwater by infiltrating into the ground. Informing stakeholders is particularly important regarding the retention of purified wastewater (greywater) from wastewater treatment plants because there are no widely adopted and accepted practices for this in the vicinity of towns and villages in Hungary yet.

12 – Buffalo Reserve at Nagyszéksós-tó. During the all too frequent periods of water scarcity the pond is supplied with greywater from the community's wastewater treatment plant. (Source: Filmever Stúdió)

2.9.6 Utilisation of rainwater around the house

13 – A simple and inexpensive rainwater collecting system for retaining and utilising rainwater around the house. (Photo: Zsófia Szabó, Bátya)

Residents can also make a major contribution to alleviating water related problems. Precipitation landing on the roof is collected and utilised by people in their own yards and gardens instead of channelling it to public areas. Thereby they reduce the load on other sections of the municipal water drainage system – ditches, canals, recipient water bodies – thereby preventing lower lying sections from overflowing or the wastewater treatment plant from being overloaded. Rainwater landing on the rooftop can be allowed to infiltrate the soil by, for instance, creating a rain garden. Rainwater can also be collected on-site in cisterns, in out-of-use, disinfected cesspits or soak pits, using an infiltration layer of gravel or in plastic tanks for later use, for example for irrigation in the garden. Plants prefer rainwater to disinfected running water and, not least, using rainwater for irrigation helps save on the water bill. Where water is collected in a closed tank, its ideal size is approx. 10 l/m^2, which is sufficient for collecting up to 85% of the annual

precipitation (in view of Hungary's average distribution of precipitation)[14], for use by irrigation or for other purposes.

Rainwater drainage and management around the house is not a municipal function but a responsibility of the owner of the property. According to the applicable regulation in force **rainwater falling on, and remaining in the area of, the property, is owned by the owner of the property.**

Encouraging residents to retain rainwater may be an effective supplementary measure on the part of the municipality.

2.9.7 Green roofs

A green roof is essentially a man-made biologically active roof surface covered by plants. The plants making up the green roof produce oxygen, absorb and bind CO_2 and dust, evaporate water, contributing to a better and healthier micro environment for residents (and all living creatures) in the town or village, by improving the quality of the air.

14 – A nursery in Budapest with a green roof. (Photo: Civertan Stúdió)

Green roofs make an outstanding contribution to lowering urban temperature and dampening the so-called heat island effect (through evaporation), effectively reducing the temperature fluctuations of the building underneath in both winter and the summer months, also contributing thereby to energy saving.

By "using up" and retaining some of the rain falling on the roof the plants reduce the amount, and slow down the flow, of rainwater, decreasing the load on the local canal network. The view of a natural environment, its spiritual effect (on people's general well-being) may be particularly important in a densely built-up metropolitan environment. A green roof can only be created on a flat roof, and it is a relatively costly project, therefore it is recommended in densely built-up urban environments where there are no other options for retaining water and creating green surface.

2.10 Co-benefits

One argument in favour of natural water retention solutions is that their integration in the community's water management system both in and out of the town or village produces a variety of other favourable impacts besides contributing to the accomplishment of their main objective. Evening out rainy and dry periods, replenishing water resources and preventing flash floods are becoming more and more important of climate change adaptation, but water retention solutions integrated into the landscape may also be **venues for recreation**. Moreover, retaining and filtering the sometimes polluted rainwater, grey water and or inland excess water may contribute to the **improvement of the quality of water and the ecological status of natural watercourses and lakes**. The creation of wetland habitats of various sizes can contribute to the **preservation of biodiversity in the Carpathian Basin**, which, in addition to promoting the attainment of environmental objectives, is also the basis of a health human environment and an effective and efficient agricultural sector. One shared characteristic of the various water preservation solutions is that they **generate a wide variety of benefits** – however, they contribute to the resolving of different problems to different extents.

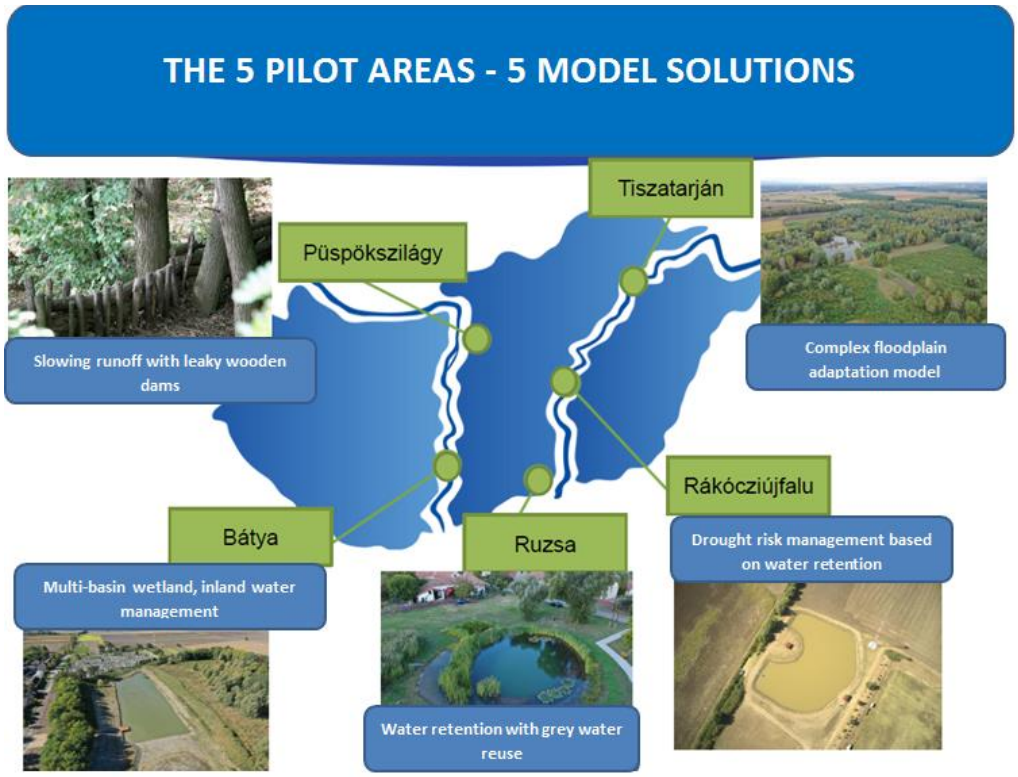
[14] Based on model calculations by Dr. Kálmán Buzás (Budapest University of Technology and Economics Department of Sanitary and Environmental Engineering).

3 RECOMMENDATION FOR MUNICIPALITIES FOR THE IMPLEMENTATION OF WATER RETENTION SOLUTIONS

3.1 Different types of municipal water management problems and possible solutions

As was discussed in earlier chapters, the global challenge of climate change and its negative impacts will not spare the populations and municipalities of Hungary and the neighbouring countries either. Indeed, climate change-induced extreme phenomena of different types and extents are already being experienced by towns and villages.[15]

This section contains descriptions of exemplary small scale natural water retention solutions designed and implemented under the LIFE-MICACC project in areas belonging to the five municipalities (of Bátya, Püspökszilágy, Ruzsa, Rákócziújfalu, Tiszatarján): One shared characteristic of these municipalities is that each of them is a village with fewer than 3000 residents and that they are particularly exposed to the negative impacts of climate change. These vulnerable villages are exposed to frequent extreme weather events (inland excess water, drought, flash flood, flood and their combinations); they are highly sensitive but have limited adaptability and infrastructural resources. Their geographical conditions, however, vary, as some are located in hilly areas, other on plains or sand ridges. They have been selected with the aim of making sure that the model solutions (prototypes) planned to be implemented under the project should set examples for the largest number of different towns and villages.



15 – The partner municipalities of the LIFE-MICACC Project and the model solutions, in brief. (Source: LIFE-MICACC Project)

[15] Report on Hungary's national disaster risk assessment system, p. 55 (*Jelentés Magyarország nemzeti katasztrófakockázat-értékeléséről*), (available only in Hungarian): www.katasztrofavedelem.hu/application/uploads/documents/2019-09/64108.pdf

3.1.1 Bátya – rainwater-retention in a wetland habitat

Bátya – Creation and operation of a municipality-owned rainwater-fed two-basin wetland habitat

This is an inspirational solution for local communities showing how wetland habitats can be used for responding to various water-related climatic events (in this case: droughts and extreme rains). The two-basin design of the pond will make sure that there is an open water surface in at least one basin while the other provides different (periodically wet) habitat conditions. This will increase the amount of local water resources to help tackle inequalities between periods of water scarcity and abundance. The pond retains Bátya's valuable water resources for dryer periods. The water infiltrates the ground to replenish groundwater while its evaporation improves the micro climate and nourishes the vegetation.

This type of natural water retention measure was tested for the first time at a local level in a municipal area through collective action. Excavation pits, or abandoned low-lying areas, are to be found outside many towns and villages, which are no longer maintained and mostly used by residents to illegally dispose of waste.

Therefore, the solution put in place serves as a practical and innovative example that can be conveniently and effectively used by other municipalities in regions facing similar water-related climate risks, by adapting it to the local conditions.

16 – Visual design of the rainwater reservoir outside Bátya. (Designer: Csilla Ruzics)

Typical problems:

The village of Bátya faces two main problems in this regard, for which the above solution is an excellent option. One of these is **severely dry weather conditions.** In recent years the village has experienced weeks passing without a drop of rain during the summer months. Given its arid conditions, the village is characterised by intensive evaporation and the amount of water so lost exceeds the annual precipitation, so the **ratio of precipitation to evaporation is negative.**

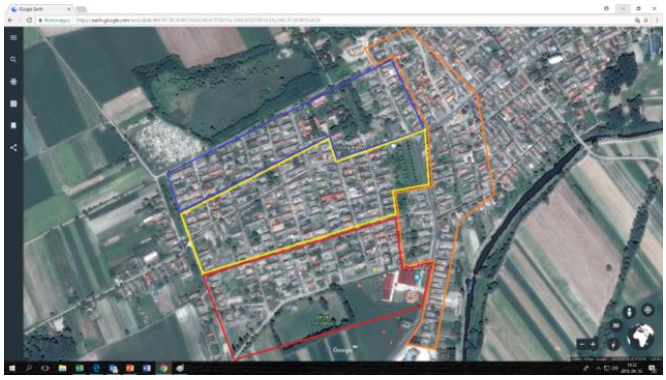
Another problem is caused by **sudden heavy rains** sometimes **hail.** The canal system has not been able to take in the large amount of rainwater so water was flowing on the streets and even inundated cellars.

17 – The venue of the pilot project, the area of a former clay pit at the edge of the village – at the beginning of the project. (Photo: Zsófia Szabó, Bátya)

The interventions implemented so far:

A 2-hectare area inside the village was renewed under the intervention, creating – after a geodetic survey – a 1-hectare useful reservoir area, with an estimated maximum storage capacity of 10,000 m^3.

The municipality aimed at protecting residents from the inundation of the village (streets, cellars), improving the local micro climate and at the same time, alleviate drought damage. Another objective was to create a new habitat to enrich the local fauna and flora, as well as to create a recreational venue for residents combining convenience with the feeling of being close to nature.



18 – Areas from which rainwater is collected in the reservoir in Bátya, by implementation phase. (Source: Google Earth)

Another development project under an application scheme was under way in the village in parallel with the implementation of the natural water retention solution, aimed at restoring the rainwater drainage systems[16], providing for the management of the large amounts of water from intense rains.

Rainwater is collected in the newly created reservoir from much of the territory of the village through these rainwater drainage systems, making it possible to retain the water for the community.

20 – Earthworks in progress in the village of Bátya. (Photo: Zsófia Szabó, Bátya)

19 – Planting trees, raising awareness. (Photo: Gabriella Szabó, Ministry of Interior)

[16]The rainwater drainage systems were restored in the village of Bátya under TSDOP-2.3.1-15 (Territorial and Settlement Development Operational Programme).

21 – Nature occupied the environment of the new pond in Bátya. (Photo: Zsófia Szabó, Bátya; Klára Kerpely, WWF HU)

23 – The finished project: two-basin open-surface reservoir pond. (Photo: Filmever Stúdió)

22 – Bátya's Mayor Csaba Fekete proudly showing the newly completed pond to Deputy State Secretary Dr. Miklós Dukai in charge of municipalities. (Photo: Gabriella Szabó, Ministry of Interior)

3.1.2 Püspökszilágy – slowing run-off in hilly areas

Püspökszilágy – Enhancing the naturalness of an extremely vulnerable small catchment area to mitigate risks

25 – Visual design of envisaged run-off deceleration solutions in the upper catchment area of Creek Szilágyi. (Designer: Csilla Ruzics)

The intervention consisted of a combination of measures implemented on the upper and the lower catchment area on pieces of land owned by the municipality. The solution is all the more of a worthy example because it combined slowing down the flow of water to avoid damage with retaining and utilising water.

24 – Visual design of the bank-side reservoir attached to Creek Szilágyi. (Designer: Csilla Ruzics)

The log dams put in place in the upper catchment area provide services reducing erosion and mitigating the risk of floods which are also beneficial for people, municipalities and farmers living and operating in the lower catchment area.

The bank-side reservoir put in place in the lower catchment area can provides venues for recreation and enhanced resilience to drought for a wide range of stakeholders. Functioning as a system the interventions resolve problems which used to be the targets of separate attempts, while the integrated solutions generate double benefits. This solution should serve as an example for vulnerable municipalities in hilly areas with limited funds but substantial natural capital.

Typical problems:

Owing to its geographical conditions the village is heavily exposed to drought. Moreover, Püspökszilágy used to experience record level flash floods once every 5-6 years earlier, and once every 1-2 years more recently, a phenomenon rarely experienced historically. At the same time, the recent few years have seen an increase in the number of heat wave days as well as the duration of droughts.

The flood waves racing downstream and the droughts cause damage to agriculture, residential areas and infrastructure alike. Flash floods carry huge amounts of materials down creeks and gullies (along with loss of material in the catchment area). On the other hand, flood waves also damage residential and public buildings.

The interventions implemented so far:

A complex natural water retention solution has been put in place in the lower and upper parts of the catchment area of Püspökszilágy. The aim is to illustrate how towns and villages can adapt to the impacts of climate change using their natural resources, including creeks, valleys and gullies.

26 – Works in progress in Püspökszilágy. (Photo: the Municipality of Püspökszilágy)

The interventions were aimed to reduce the village's exposure to the more and more frequent flash floods down Creek Szilágyi and at the same time to strengthen its resistance and defence capabilities. The bank-side reservoir's function is to reduce the damage caused by water locally. During periods of water scarcity the reservoir also functions as a refuge[17] *for wildlife – as a wetland throughout the year – improving at the same time the local water budget during periods of heat waves and droughts by maintaining the groundwater table, by evaporation and by water retention.*

In the wake of an earlier flash flood the municipality commissioned the dredging of a bank-side reservoir and a drainage ditch combined with a groundwater pond in the area of Püspökszilágy as a defensive measure, to reduce damage caused by floods. Further development of the water facility developed earlier to reduce local water damage took place under the LIFE-MICACC project for purposes of protection against climate change (in addition to reducing flood peaks) in a carefully considered framework determined by designers and contractors.

<u>The following hydraulic facilities were put in place:</u>

Bank-side reservoir hydraulic facilities were constructed on the left bank of Creek Szilágyi, with the primary aim of **water retention and the creation of a wetland habitat.**

27 – Construction operations in progress in Püspökszilágy. (Photo: The Municipality of Püspökszilágy)

The reservoir is also suitable for:

- taking in extra amounts of water brought on by flash floods caused by heavy rains to reduce flood peaks in the village as a preventive measure;
- to alleviate extreme situations regarding the local water budget and to facilitate the replenishing of groundwater during droughts and heat waves;
- functioning as a refuge for aquatic species or species thriving in wetland habitats.

A total of **4 sediment traps** constructed in the previous century **using quarry stone** used in hydraulic engineering were excavated and reconstructed as part of the project, in the upper section of Creek Szilágyi.

[17] Refuge: a small area making up a specific habitat, different from its environment, in which animal species finding themselves in an extra-zonal situation as a consequence of changes in the environmental conditions can take shelter (this meaning of the word is used in biology).

A total of **7 log dams** were also constructed – based on lessons learned in an international study tour focusing on natural water retention solutions applied abroad – in beds of periodic watercourses carrying soil and water from the agricultural lands on the hillsides above the village.

The lifetime of a log dam is – according to international experience – about 8-10 years. Thereafter the ageing and weakening of the logs necessitates reconstruction. Even so, experience shows that from the aspect of cost effectiveness this semi natural water retention solution is less expensive – including the costs of reconstruction – than technical solutions of conventional hydraulic engineering relying on reinforced concrete structures. According to the position statement issued by the competent water protection authority the construction of log dams at Püspökszilágy does not qualify as an activity necessitating a water rights establishment permit from the water management authority.

28 – Log dams at Püspökszilágy during the dry period, and “at work”. (Photo: Ministry of Interior, Püspökszilágy Municipality)

29 – The greenery of the newly constructed bank-side reservoir attracting people seeking recreation. (Photo: Gabriella Szabó, Ministry of Interior)

3.1.3 Ruzsa – water scarcity and greywater utilisation[18]

Ruzsa – Withholding of greywater to replenish groundwaters

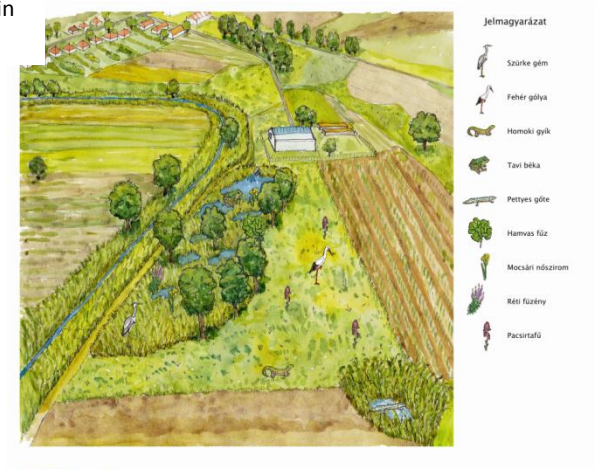
There have been no previous examples in Hungary for the replenishment of groundwater through the retention of greywater, despite the fact that the currently used wastewater and drinking water treatment technologies produce decant water of adequate quality. The interventions executed at Ruzsa involved solutions utilising decant waters from wastewater treatment plants and the processes of drinking water treatment, as a valuable resource. Drinking water quality improvement projects have resulted in an ever wider use of drinking water pre-treatment technologies in the Hungarian Great Plain, but decant water is not retained and used in any of those projects.

In the Ruzsa pilot site under the LIFE-MICACC project greywaters are collected in a small pond for infiltration into the soil, contributing to the replenishment of the underground water resources and mitigating the risk of groundwater table sinking.

31 – Design of the pond to be created by retaining decant water in Ruzsa's Dózsa Park. (Designer: Csilla Ruzics)

Based on experience from Ruzsa it is important to recognise that regions of extreme water scarcity should consider the retention of greywater, as a local solution, a local form of resource utilisation.

Another important element of the interventions in Ruzsa is natural water retention in ditches owned by the municipality. Natural water retention measures jointly operated by the municipality and land users are to be regarded as good practice, to be adopted with regard to the total of 50,000 kilometres of ditches and canals in Hungary.



30 – The visual design of the wetland habitat relying on decant water from the waste water treatment plan of Ruzsa. (Designer: Csilla Ruzics)

Typical problems:

Changes in the region's dominant hydrological factors have made a profound impact on the landscape in a relatively short span of time. As a result of lack of precipitation primarily during the winter months – water from melting snow infiltrates the soil but dry winters have become a regular phenomenon – the groundwater level has started to sink between the rivers Danube and Tisza. Wetland habitats have

[18] Greywater is a collective term for all kinds of wastewater generated in a household – except for the wastewater that contains faeces – which, if collected, can be used without treatment for flushing toilets, cleaning/cleansing and irrigation. Forrás: www.antsz.hu/data/cms42272/vizes_GYIK_egyeztetett.pdf (available only in Hungarian)

practically disappeared and been replaced by sand dunes driven by the wind in the region, as a consequence of decades of dry weather and the sinking of the groundwater table. The slow aridification has lowered the groundwater table by 3-5 metres[19], causing gradual degradation and destruction of the top layers of the fertile soil. In addition to the stress suffered by vegetation, however, the scarcity of water has a severely negative impact on agriculture, forestry, residential areas and the drinking water supply of towns and villages as well. "According to the FAO the causes lie in global climate change and wrong agricultural practices, i.e. they are both natural and human-induced processes.[20]

Topographically, Ruzsa lies at a relatively high altitude. Consequently, the ground is characterised by rapid infiltration and movement of water, resulting in a poor water retention capability, so the village is even more exposed to negative climate change-induced impacts. The situation was further aggravated by the adoption of wrong environmental management strategies, including water-intensive agricultural production, and inadequate management and maintenance of the canal network.

The interventions implemented so far:

The above factors have made Ruzsa and its environment extremely vulnerable to drought and water scarcity. The only successful solution to the problem may come from an integrated natural water retention intervention, covering both the inhabited area of the village and the areas around it, for which Ruzsa has used the following natural and artificial resources:

- The Honvéd-Forest canal network constructed **around the village**. The canal was originally designed for groundwater and inland excess water drainage; thanks to the natural water retention intervention however, it became suitable for water retention as well. One completely new water retention structure was constructed and two water retention structures were renewed in three sections of the canal system, and one discharge facility was also constructed. The structures enable discharging the inland excess water typically onto meadows and pastures. This enables the village to facilitate infiltration for replenishing the groundwater reserves as required by arable lands and the ecosystem in general.

– **Retaining decant water** (greywater) from water treatment facility removing arsenic from the water on the premises of the local water company in the village's **inner area** in Dózsa Park. This decant water used to be discharged into the main canal, thereby removed from the area of the village. This is a low-lying area, connected with the local waterworks by a closed pipeline system. The local waterworks releases 10-15 m^3 of decant water a day, which is carried to Dózsa Park through a pipeline where a small (approx 700 m^2) water reservoir has been put in place by removing sand from the site and by constructing a small dam.

The collection and use of the locally discharged greywater also contributes to making the village's environment greener. The environment created around the reservoir (including a BMX track and benches) is an excellent venue for recreation and for use as a community space, for local residents and visitors.

32 – Shaping a varied lake bed surface for the local pond at Ruzsa. (Photo: WWF HU.)

[19] https://www.hidrologia.hu/vandorgyules/34/dolgozatok/word/0109_meszarosne_bunasz_nikolett.pdf (only available in Hungarian)

[20] https://www.alfoldinfo.hu/homokhatsag/ (only available in Hungarian)

33 - The lush green of the pond created in the village of Ruzsa awaiting residents. Filmever Stúdió)

- Decant water from the treatment of wastewater (greywater) is retained **also outside the village boundary, near the waste water treatment plant.** The plant's output of treated wastewater is 150-200 m^3. This amount of water is retained in a reservoir pond of about 1350 m^2. The infiltration of water is a process aimed at reversing harmful soil transformation processes and mitigating the risk of drought.

The combination of the above three natural water retention solutions in the village is an innovative solution just like the retention and use of greywater for adaptation, thanks to which the above measures may serve as model solutions in other aridifying areas between the rivers Danube and Tisza, and in other areas of Europe facing the threat of drying out, in their efforts of adaptation to climate change impacts. The above water retention measures enable Ruzsa to demonstrate how local small-scale natural water retention interventions can be combined to promote climate change adaptability.

34 –Intervention area behind Ruzsa's waste water treatment plant. (Photo: WWF HU.)

35 – Works on the construction of the pond outside Ruzsa behind the waste water treatment plant.(Photo: 1. WWF HU.)

36 – Bird's eye view of the water retention solution outside the village. (Photo: Filmever Stúdió)

3.1.4 Rákócziújfalu – storage of inland excess water by the municipality

Rákócziújfalu – Risk management based on water retention involving canals

37 – Future vision of a reservoir of inland excess water, Rákócziújfalu, at the time of high water level (Designer: Csilla Ruzics)

Local communities are not prepared for water-related risks associated with the climate change and this pilot site is extremely highly exposed to inundation by inland excess water as well as to increasing water scarcity, which is only aggravated by intensive agricultural practices. The ditches and canals, as well as natural depressions, in the village however, can take in and store excess water (accumulating in the form of inland excess water or after heavy rains), the retention of which helps mitigate the risk of droughts. This can serve as a prototype of a solution for regions where agriculture has a major impact on water resources. The there are thousands of such lower-lying areas or depressions in the former Tisza floodplain but no attempt has yet been made at utilising them to mitigate climate change-induced risks (inundation by inland excess water, downpours and droughts). Were this small-scale water retention model to become a widely adopted good practice in the region, applied by many of the communities concerned, it could also contribute to the alleviation of climate vulnerability at a landscape level.

Typical problems:

The region lies in the midsection of the Tisza basin, an area extremely highly exposed to risks of **floods**, **inland excess water**, **heat waves** and **heavy rains.** Of the above risks inland excess water is special characteristic of Hungary's hydrological conditions, affecting some 45% of its territory, particularly in the Great Plain.[21] The excess water is caused to accumulate in the low-lying parts of the Tisza basin partly as a consequence of specific meteorological, hydrological and morphological circumstances and partly as a consequence of human activities (wrong agricultural and forestry practices outside towns and villages as well as building up low-lying areas in towns and villages). Water from quickly melting snow or a heavy rain, or when the groundwater table is already high, water from any rain, cannot naturally infiltrate or otherwise drain from the area. Ultimately, the excess water cannot drain from the area because the natural routes through which it used to reach the river were blocked by the embankments constructed as a means of flood protection. Consequently, inland excess water can cause major damage in the areas concerned to agriculture, infrastructure as well as in the towns and villages themselves. With adequate water management however, it can be regarded as a useful resource, therefore it is not right to consider inland excess water as "harmful water".[22] The use of part of the inland excess waters accumulating at the end of the winter and in the spring at a later time, during periods of water scarcity and droughts, is called **inland excess water utilisation**.

Inland excess water utilisation relies on the storage of inland excess water in natural and/or man-made reservoirs or on arable fields.[23]The water so stored can be used later during periods of water scarcity

[21] https://katasztrofavedelem.hu/287/katasztrofatipusok-belviz
[22] http://vpf.vizugy.hu/reg/ovf/doc/14.%20Belvizmentesites,%20belvizvedelem_A1.pdf
[23] http://vpf.vizugy.hu/reg/ovf/doc/14.%20Belvizmentesites,%20belvizvedelem_A1.pdf (the documents are available in Hungarian only)

for irrigation or for supplying fish ponds, saving the costs of the operation of expensive electric water pumps and irrigation systems for the farmers concerned. At the same time, the village experiences heavy downpours, causing inundations, more and more frequently as a consequence of the climate change. Rákócziújfalu's vulnerability is aggravated by the fact that it is located in one of Hungary's driest regions, as a result of which heat waves have been growing more and more frequent and the risk of drought has become extremely high.

The interventions implemented so far:

To enhance its adaptability the village first identified its most important local resources (canals and natural depressions) with the aim of **retaining rainwater and utilising it on site**, as well as to **mitigate the risk of floods**. Rákócziújfalu used the following key identified natural and man-made resources for natural water retention:

- A **canal network** outside the village called Falusi 1, initially constructed in order to drain swamps and waterlogged areas. This canal is used – besides storing inland excess water and rainwater – for supplying the artificial reservoir pond with water.

38 – Pond construction in Rákócziújfalu. (Photos: József Varga, Rákócziújfalu)

- **Geomorphological depression** of natural origin (a low-lying area) right between the village and the river Tisza, which used to be utilised as a low-quality arable field and formed part of the floodplain. There are thousands of similar geomorphological depressions in the former Tisza floodplain, including primarily former riverbeds, oxbow lakes, drained marshlands, not utilised so far with the aim of mitigating climate risks. Relying on the area's geomorphological features, 0.6 ha (6000 m^2) wetland habitat has been created, which is supplied with water from the above mentioned Falusi 1 canal to which Rákócziújfalu's inner rainwater drainage network will also be connected in the future. Water could also be supplied from the Nagykunság Main Canal and a nearby fish pond from which it will be possible to supply the local pond through the same local canal and it will also be possible to store water in the canal bed itself which is another crucially important element of integrated natural water retention.

40 – Table and benches.

39 – Information board around the pond

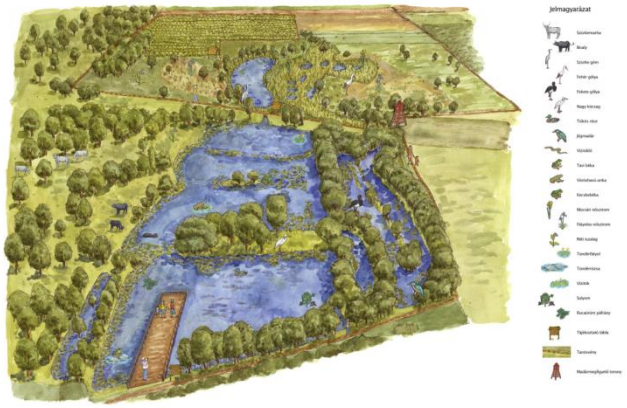
By utilising the above resources Rákócziújfalu is capable of successfully implement the adaptation measures necessitated by inland excess water,

heavy downpours and droughts. Areas of a total of at least 2 million hectares are affected by similar water-related risks in Hungary, therefore the solutions put in place should serve as a model for other towns and villages having similar characteristics and facing similar problems in Hungary and even abroad.

3.1.5 Tiszatarján – floodplain water retention and water management

Tiszatarján – Complex floodplain adaptation model

Adaptation to climate change in the flood plain through controlling invasive plants [24]*and water retention is an innovative approach aimed at enhancing flood safety simultaneously with reversing a trend of deteriorating ecological status caused by the growth of invasive plant species in the floodplain. Controlling invasive plant species and restoring the former floodplain pasture not only increases the floodplain's floodwater holding capacity and reduces its surface roughness, but also support the natural habitat storing the water and effectively facilitating its distribution in the landscape. Ecotourism based on the restored landscape and the use of the biomass sustainably grown in the floodplain, as a renewable energy source, render the model economically sustainable as well. This solution is a good example for other local communities along the River Tisza and its tributaries, which are growing more and more vulnerable to climate risks and water-related risks.*



41 – Visual design of the proposed enlargement of the buffaloes' pond in the Tiszatarján floodplain (Designer: Csilla

Typical problems:

One of the key signs indicating the vulnerability of the village is the rapid **spread** of **invasive plant species** (including *Amorpha fruticosa*), particularly in the floodplain, aggravating the risk of flood because by increasing the floodplain's surface roughness it slows down the passing of flood waves. Moreover, these harmful plant species degrade biodiversity and weaken the naturalness of the ecosystem, cause an increase in the costs of land use because by their rapid spread they crowd out native plants, indeed, in agricultural areas they compete with the crops intended to be grown.

Under the "One Europe – More Nature" (hereinafter: OEMN) programme the village already launched an innovative pilot project in its floodplain back in 2006. The project was started with the eradication of *Amorpha fruticosa* plants (they were ultimately utilised as biomass). Biomass is used by the village locally for heating its own public institutions, while a smaller part of it was delivered to a nearby thermal power plant. Thereafter, the extensive areas that used to be covered by *Amorpha fruticosa* were planted with native willows (*energy willow, Salix viminalis*), which provide a sustainable long term supply of biomass for heating municipal buildings. In addition to growing energy willows, Hungarian grey cattle and water buffalo herds were brought in to graze parts of the floodplain area, to prevent the reappearance of the invasive plant species.[25]

[24]Invasive plant species: a plant species that is not indigenous, not characteristic of the given landscape. The spreading of invasive species is one of the key factors threatening natural and semi-natural habitats. A considerable number of plant (and animal) species threaten the diversity of indigenous local plant (and animal) communities and cause habitat impoverishment in areas far from their their original habitats, through intentional or accidental introduction in areas where they are not native.

[25] http://tiszatarjan.hu/wwf-egyuttmukodes-tiszatarjanban/ (available only in Hungarian)

The interventions implemented so far:

The OEMN programme however, did not cover everything. Three more key elements were required for complementing and presenting the executed measures as an ecosystem-based adaptation model, which the municipality of Tiszatarján implemented under the LIFE-MICACC Project:

42 – Installed water level gauge at Tiszatarján. (Photo: the Municipality of Tiszatarján)

1) Execution of small-scale natural water retention intervention in the floodplain: creating permanent open water surfaces in the area of excavation pits and connecting them with each other to function as a single connected permanent water surface. Through infiltration to the groundwater they provide agriculture with a natural water supply and serve as a habitat for waterfowl and amphibians where they can breed, feed and find shelter, as well as for grazing livestock. The wetland habitat is also suitable for storing inland excess water accumulating on arable fields.

2) Development of local ecotourism in the restored floodplain as a local revenue source to alleviate dependence on agriculture, a sector that is particularly vulnerable to climate change impacts. In this context a nature trail was created, complete with information boards, in the wetland habitat and the system of small pons.

43 – The system of excavation pits supplemented with a new basin. (Photo: Gabriella Szabó, Ministry of Interior)

3) Also, there are plans for affording **legal protection** for the pilot site, to ensure the sustainability of the investment project, by bringing the site under local protection.

The **combination of** local bioenergy generation, the repression of invasive plant species, water retention, semi-natural grazing and ecotourism **offers an effective adaptation model** that may serve as an example for other towns and villages facing similar problems in Hungary as well as municipalities in other EU Member States. These natural water retention measures – and their demonstration – generate multiple benefits for other stakeholders, such as local residents, farmers, fisheries and the municipality. In the wake of the above measures the current land use practices are being gradually replaced by a more sustainable structure.

44 – Both buffaloes and grey cattle appear to enjoy themselves in the area. (Photo: Gabriella Szabó, Ministry of Interior)

45 – Panorama photo of the pond and the pier. (Photo: Éva Burai-Hajdu, Tiszatarján)

3.2 The steps of implementing a natural water retention solution

In the following two sections we describe the entire process whereby natural water retention solutions are created, including the various steps of the process and the details to which particular attention needs to be paid.

3.2.1 Climate vulnerability assessment, identification of local resources enabling the assessment

The importance of the vulnerability assessment (VA)

Climate change has a variety of negative impacts on society, the economy and our day-to-day lives. Climate extremes and natural disasters are causing more and more damage and cost a lot of money for communities. The vulnerability assessment is a useful tool for establishing the climate change-induced vulnerability of a town or village (exposed sectors, frequent incidents in which damage occurs) and for mapping and ranking the available local resources and possible interventions. It enables – based on nationwide or local data – the identification of how a given town or village is vulnerable and where it needs urgent intervention, or whether there are areas (even in municipal ownership) where a possible solution identified by the VA could be implemented. The overarching goal of the assessment of risks and exposure is to inform decision makers about potential climate change-induced local risks and the possibilities of mitigating them.

The benefits of a vulnerability assessment

- The situation, resources, challenges, risks and opportunities of a given town or village are examined in a complex way, covering all relevant fields and specific areas, to generate an overview of its vulnerability.
- The community's adaptability and its preparedness for responding to extreme climatic and weather events can be improved.
- An assessment of locally available resources helps increase the efficiency of their utilisation, for instance, in abandoned or unused areas in and around the community, through reconsidering their functions.
- This process makes it possible to get to know local stakeholders' opinions and experiences as well as their proposals and recommendations for solutions which may help strengthen the local community.

"Being aware of the community's vulnerability is key. Interviewing local residents and farmers is indispensable for identifying endangered areas. It was concluded from the maps of the National Adaptation Geo-information system (NAGiS) that health and agriculture are the most vulnerable sectors in the village. Interviews with residents, the data we collected, the information from NAGiS and regular local site visits together helped us put together a well-founded vulnerability assessment." Tibor Kulcsár, municipal officer for climate change, Tiszatarján

The usability of a vulnerability assessment

A VA may provide a solid foundation for preparing a municipal climate strategy; its content can be used, and integrated, in local plans and strategies. Moreover, since the European Union is also paying more and more attention and it is providing funds for grant applications for projects relating to climate change adaptation, the municipality may even be able to realise project concepts contemplated in, and elaborated on the basis of, a vulnerability assessment, with the help of EU funding.

The steps of a vulnerability assessment

The following is a list of the most important pieces of information to be taken into account, together with the key steps of carrying out a VA:

- **Analysis of the basic situation, collection of data (from databases, local stakeholders, interviews)**
- **Evaluation of data and impacts**
- **Evaluation of adaptability**
- **Mapping and elaboration of possibilities for adaptation**
- **Studying good examples (e.g. climate strategies, proven solutions of other towns or villages)**

The detailed description of the various steps of the preparation of a VA is available at, and can be downloaded from, the Document Library on the LIFE-MICACC Project website.[26]Our recommendation is that it should be reviewed before the preparation of a VA.

What will be required for the preparation of a VA?

- The municipality designates a person to be in charge
- "Vulnerability Assessment" excel spreadsheet (to be downloaded from the Document Library)
- Structural plan of the town or village
- Topographic map of the town or village
- Orthophoto (aerial photo or satellite image) of the town or village, preferably also in a large-sized printed form and in a digital version
- Stakeholder cooperation

A vulnerability assessment may also be carried out by the municipality's staff; in this way, their knowledge of the community, the local conditions and circumstances adds to the efficiency and effectiveness of the exercise. The municipality's own sources of data, experience and information in national databases, can also be used. Information may also be asked from the state administration bodies and authorities that are competent in the area. Contacting specialised experts to gather more detailed information on the sectors that have been identified (including universities, water management directorates, national park directorates in the region) may also help prepare materials of technical/professional relevance that can actually be used in climate adaptation. Interviewing, and involving, local stakeholders, professionals and residents, in the preparation of the assessment, makes the document more well-founded and more widely accepted, therefore this should also be contemplated (for details, see chapter 4).

3.2.2 Design and other technical matters

Designs to be submitted to the water management authority with the request for the required authorisations permits need not be prepared for many natural water retention solutions. Such solutions include, for example, the reforestation of arable fields, increasing green surfaces in towns and villages, changing agricultural practices. However, solutions resulting in the creation of new permanent water bodies, changing the patterns of the way water flows down watercourses or the input and output conditions (flow regimes) of lakes, require the preparation of plans/designs to be submitted to the water management authority for authorisation, and the issuance of the required authorisations by the same, in Hungary.[27] Authorisation, and planning/design, is required because the

[26] Annex on the steps of a VA (pdf.): https://vizmegtartomegoldasok.bm.hu/storage/dokumentumok/Steps%20of%20the%20preparation%20of%20a%20vulnerability%20assessment.pdf

[27] The list of water facilities and water works that require a water right permit procedure is contained in Government Decree 72/1996 (22 May) on the exercise of water management authority (legislation in force in Hungary).

solution has to be aligned to the existing water systems inside, as well as outside, the town or village concerned, because in most cases catchment areas do not fully overlap municipal administrative territories. The sizing of hydraulic facilities is also key; an undersized structure or piece of equipment etc. can only partly solve problems or break down under the first massive load. Oversizing, on the other hand, involves unnecessary occupation of areas or unnecessarily increased costs of implementation and maintenance. The following advice provides assistance with the procedure of obtaining the necessary authorisations and licences, as well as the implementation of the project:

A) Outlining of design concepts

This task should be assigned to a practising hydraulic engineer, with the involvement – in the development of the concept – of a landscape architect or a natural conservation expert. The municipality plays a dominant role in the preparation of the concept variants and in the selection of the best one, therefore, the designers should consult the **municipality's representatives** and key local stakeholders **who have a profound knowledge of the problem at hand**, over and over during the process. What the preliminary assessment should, by all means, clarify:

- The locations of the **areas suitable for water retention** inside or outside the village or town.
- The sources from which (e.g. inland excess water, rainwater, greywater), and the way (e.g. gravitationally, through pumps, pressurised), **water** can end up in the potential area.
- **Ownership** of the areas to be involved in, or affected by, the intervention. Can it be implemented on municipal land or will it affect others too? If the answer is yes: is the owner or user of the land willing to collaborate in water retention? Are they willing to issue a declaration of consent or cooperation and sign a cooperation agreement later on?
- Who will take possession of the facilities to be created?
- What **co-benefits** are to be expected in addition to tackling the problem concerned?
- Does the intervention involve or affect any **nature conservation area** of national importance? Such areas include those of the National Ecological Network, Natura 2000 sites, natural areas under national protection and "*ex lege*" protected areas. In their cases the nature conservation authority issuing licences or authorisations needs to be involved.
- What forms of land use are practised in the area. Is there a need for **changing the type of land use or withdrawal from agricultural production** in order to implement the project concerned? What are its estimated costs?
- **Estimating the cost of construction**: the approximate amount (m^3) of earth to be moved, what structures need to be put in place and how much they cost. The value of the earth works may be substantially reduced by seeking for an investment site that is already suitable for retaining water, e.g. material extraction sites (see: Bátya), excavation pits (see: Tiszatarján), low-lying flat areas, waterlogged arable fields (see: Rákócziújfalu), oxbow lakes, canals (see: Ruzsa).
- Estimating the **maintenance requirements** and costs of the water retention solution. Who would perform the tasks of maintenance?
- The **effectiveness** of the water retention solution: approximately how many m^3 of water can be retained in the area concerned?
- How does the intervention relate to the **future village or town development goals** (e.g. designation of new residential areas, planned routes of new roads etc.)?

Mapping of, and learning about, the intervention area (e.g. concerning the presence of protected species, land usage type, terrain/topography, accessibility for heavy machinery, ownership conditions etc.) is indispensable for answering the above.

B) Technical/professional criteria for the selection of the experts/designers to be involved

Representatives of multiple fields of expertise need to be involved and their work needs to be coordinated in designing nature-based solutions.

I. Hydraulic engineer

One key criterion in selecting and commissioning the designer is that they should have a degree in hydraulic engineering and be a registered member of the chamber, because without these they are not authorised to prepare designs to be submitted with the application for a construction permit. Moreover, the following considerations should be taken into account:

"The selection of a good designer is key, and putting together a good team is just as important. All of the members should be committed to environmental protection and they should also be proponents of water retention." Csaba Fekete, Mayor, Bátya

- **References**: prior experience regarding nature-based solutions.
- Profound **knowledge of the location**.
- Existing good **working relationship with the locally competent water management directorate.**
- **Short distance to the designer's registered office**: making it easier to carry out the site visit, which often needs to be repeated multiple times, and consultations, required when working out the design concept.
- A history of prior cooperation with the municipality.

II. Ecologist, nature conservation engineer

If the intervention involves a protected nature conservation area or a Natura 2000 site, a nature conservation work element needs to be prepared for the necessary authorisation or licence to be obtained, which requires the involvement of an professional with a qualification in ecology, landscape architecture or nature conservation engineering. An ecologist designer should also be involved even if the intervention is to take place in an area that is not under protection for nature conservation. They help create a water retention solution that fits in with the landscape, operates naturally and constitutes a self-sustaining system with minimum maintenance requirements. If there is any public or civil society organisation in the town or village that is engaged in nature conservation, they should also be contacted because they may even carry out the task at hand.

III. GIS expert

The involvement of a GIS (mapping) expert may facilitate the planning/design process. GIS software can help municipal actors carry out spatial analyses and work out plans at the level of the town or village.

C) Laying down responsibilities in the contract to be concluded with the designer

It is important for the municipality that the **designer provides comprehensive service**, including the preparation of the design(s), putting together the technical documentation and obtaining the necessary authorisations and licences. The following should be negotiated, and stipulated in the contract:

- **Who will carry out or commission the geodetic survey and soil mechanics drilling that will be required for the preparation of the design(s)? Who will communicate with the competent authority?** Understanding and answering questions and the submission of missing elements often requires hydraulic engineering expertise.
- **Putting together the documents to be submitted with the application for the required authorisations and/or licences, obtaining authorities' consents and taking the required**

measurements are the designer's responsibilities. It is usually impossible to draw up an exact list of the necessary items in advance and producing them may entail extra costs. If such costs are to be borne by the designer according to the contract, they will probably undertake the assignment for a higher price, while if they are to be borne by the municipality, it may have to pay some unexpected cost items. Therefore, in the latter case a specific amount should be budgeted in addition to the designer's fees for this purpose and to cover any procedural fees that might be charged by the competent specialised authorities.

- The designer should be asked to provide **designer's site supervision** service for the duration of the construction of the structure in the course of which the designer monitors the works and deals with any conflict.
- The **documentation of the operating permit** should also be put together by the designer, and then submitted by the municipality. If the project is to be financed by some grant, the designer may also be commissioned to work out its technical/professional part or the entire application documentation. In such cases the generally accepted solution is the conclusion of a contract stipulating a "success fee".

In case the project is to be financed from a grant, the designer should be informed about the background of the application scheme and relevant special requirements before the conclusion of the contract. The integration of the requirements in the design should be ascertained at a later stage as well.

The steps of the design process in accordance with the applicable domestic legislation in brief (with the responsible persons/organisations between brackets):

1. Identification of the development requirement, launching of the design process (municipality).
2. Selection of the designer, conclusion of the contract (municipality).
3. Preparation of concept designs (designer).
4. Asking the relevant specialised authorities for preliminary position statement (recommended: designer).
5. Based on these, asking for outline water rights establishment permit, e.g. for the submission of the application (designer)
6. Preparatory surveys: geodetic survey, soil mechanics investigation (designer, or contractor contracted by municipality).
7. Working out the designs to be submitted in the application for a water rights establishment permit from the water management authority; in the case of smaller projects this may be of sufficient detail for use as construction design (designer).
8. Taking any additional measurements/elaborating additional designs as may be prescribed by the authorities (e.g. humus preservation plan, environmental impact assessment) (designer or contractor)
9. Obtaining consents/authorisations from owner and authorities (recommended: designer).
10. Obtaining authorisations/licences (authority issuing water rights permits).
11. Preparation of construction designs, unless already worked out (designer).
12. Construction/implementation. Designer's site supervision should be requested (contractor, designer).
13. Preparation of the as-built design documentation (contractor).
14. Obtaining water rights operation permit (designer).

D) Various technical/professional considerations to be taken into account in the design process

Technical considerations

- It is important that surface water should reach the wetland habitat **gravitationally** without the use of pumps. The inlet points and bottom depth should be designed with this requirement in mind.

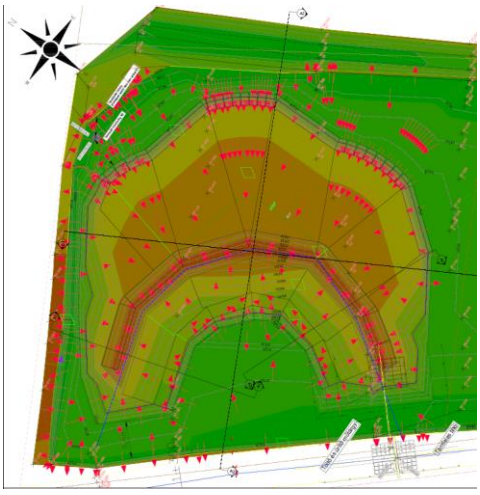
- The wetland habitat should be designed with the aim of **minimising the amount of earth to be moved** since this is often the largest single cost item in construction (moving 1 m^3 of earth cost HUF 3-4000 at the time of the drafting of this paper). Another important consideration is that the excavated earth should be used "in the project site" (which may involve pieces of land under different topographic lot numbers) because transporting earth is extremely costly and in such cases the mining authority must also be involved and a mining royalty must be paid.
- **Water quality**: when treated wastewater, decant water or water containing any other contamination or nutrients is retained, it should be kept first in a **settling pond** for a while.
- The flow of the water in a wetland habitat can be controlled by locating inlet and discharge points as well as by dredging ditches to guide the flow of water. **Flowing water has a higher oxygen content**, it does not "go stale" so easily; making sure that there can be no places in the wetland habitat or reservoir with stagnant water contributes to maintaining good water quality.
- If soil mechanical drilling finds subsoil layers of high filtration factors, such as sandy subsoil and the groundwater table is deep below ground, but the aim is to create an open water surface, a **watertight layer** (clay, HDPE foil or bentonite plate) may need to be put in place on the bottom of the reservoir and along its sides up to a certain height, to prevent the water from quickly seeping away. The top layers should be left insulated, or a separate infiltration basin should be created, to make sure that when the reservoir is overfilled the excess water can infiltrate the soil so that it is retained in this way. Insulation is justified only in the case of very small ponds, in residential areas where it is important to keep up an open water body.
- The site's **easy accessibility** for machinery is an important factor from the aspect of costs.

Ecological criteria

46 – A varied irregular basin geometry created in Ruzsa. Flat slopes and stepped embankments were built in alternation, taking closer attention and work on the part of the contractor and even reducing the volume of the reservoir in comparison with one with the steepest possible slope. A less steep bank however, is both safer and makes a more versatile habitat for aquatic wildlife. (Photo: V. Mátyás Farkas, HU)

A newly created wetland habitat always looks desperately barren after the earth works but it does not take more than a few months for nature to take possession of the site. The quick settlement and long term survival of a varied and rich wildlife is greatly facilitated by the following:

- The geometry, depth and other parameters and conditions of the wetland habitat should be similar to **wetland habitats existing in the landscape**; they should be as natural as possible.
- An **irregular, varied contour is recommended**.
- **Sections** of stepped embankments and straight slopes should be created **in alternation**.
- **Slopes as flat as possible or stepped embankments** should be created at the edge of the wetland habitat or pond. Stepped embankments create areas of different altitudes. The shallow parts of the basin, typically covered by up to 1,00 metre of water, are suitable for



47 – The inland excess water reservoir is similar to a cut-off oxbow lake in terms of both shape and river-bed geometry. Irregular shore line, asymmetric cross sections and varying lake bed depths are to be seen. The 2-metre deep graben alongside the horseshoe-shaped lake bed helps fish survive the winter. (Designer: Iván Balla, Ferenc Máriás)

various vegetation types preferring river banks or lake shores, enabling the growth of a patch of reeds, rushes, sedges and pond weeds, an indispensable element of a wetland habitat. It is only in the deeper parts that an open water surface is maintained.

- **Suddenly deepening parts** main be created in some places where there is an open water surface right next to the shore.
- If there is a risk of the wetland habitat going completely dry during a period of extreme drought, there may be a need for designing **artificial water supply** to preserve the aquatic wildlife. Water may only be supplied from surface waters, with a licence. (At the same time, the flora and fauna of a wetland habitat – apart from fish – tolerate periods without water, indeed, some species only appear periods of water cover alternate with periods without it.)
- Shallow **waters that are not accessible for fish** provide an excellent **breeding ground** for protected and increasingly rare amphibians.
- **Native old trees** in the area should be spared even if they are in the way of heavy machinery.
- Exclusively **native flora and fauna should be introduced** both on land and in water. The presence of aquatic plants contributes to the pond's oxygen balance and nutrient cycle; their growth can be regulated and may help prevent excessive algae growth. The introduction or transfer of protected species requires nature conservation permits which can be requested from the environmental and nature conservation authority.

Economic and social considerations

- The project should be designed so as to **minimise its maintenance costs** and make the maintenance tasks as easy to carry out as possible.
- Reservoirs created with the aim of water retention may also be used for **recreational purposes**. This should be taken into account in designing the shape of the shore and the depth of the pond. One good solution is where one half of the pond serves for ecological purposes (as a habitat), with undisturbed semi natural vegetation, while the other half is designed for recreation. Public use, for recreation, usually requires a certain **permanent open water surface**.
- The shore on the recreational part of the wetland habitat should be as flat as possible **for the safety of the users**. A steep slope can be slippery and where the water deepens too quickly there may be a risk of people drowning.
- If the pond is also to be **used for angling** it should be **at least 2 metres deep** for the fish to survive the winter.
- The excavated earth can be used for shaping the terrain of the recreational area, i.e. for building islands, a mound for tobogganing, a BMX track etc.
- The **use of locally available materials** is usually both cheaper and results in solutions better fitting into the landscape (see the log dams at Püspökszilágy).

Example: Construction of sediment traps for the Püspökszilágy storm water reservoir

Large amounts of water carrying a lot of material flow into the storm water reservoir through two inlet points, from a hilly area with arable fields and through gullies formed by erosion If this were to be discharged right into the reservoir, the material carried by the water would settle and quickly fill up the reservoir which would necessitate discharging the reservoir or manual dredging. To avoid this, 3 m^3 pits were constructed, of concrete slopes and floor at the inlet points to function as sediment traps. The traps are easily accessible for mobile machinery. The sediment settling in the pits can be removed with machines or even manually, protecting the main reservoir from silting up. The valuable humus-containing top soil so recovered can be used in agriculture

Case study: Coordination of multiple design criteria through an iterative design process (with multiple consultations) in Bátya

The Mayor of the village represented the local population's interests, with a focus on low development and maintenance costs, while the designs of the village's rehabilitated wetland habitat for the collection of run-off from rainwater were being developed. The design engineer concentrated on technical feasibility and safety, as well as on keeping to the budget, while the experts of WWF Hungary as well as the ecological designer promoted the interests of nature conservation. The designs of a complex, multi-purpose wetland habitat, meeting a variety of requirements and criteria, were worked out during the rounds of consultations.

1. A solution **fitting into the landscape**: the wetland habitat was created in a former excavation pit. Thanks to the pre-existing depression the new reservoir fit into the landscape and less earth had to be excavated for its construction, and the hitherto abandoned area was also tied up as part of the project.

2. The reservoir consists of **two separate basins**, a deep one and a shallow one. The deeper basin always contains water to enable aquatic flora and fauna survive droughts while of course the shallow basin dries out during periods of droughts. There was a demand for a **permanent water surface** among local residents as well, and the minimum 2 metre depth – even if only in a small area – makes it possible for fish to survive the winter.

3. During extreme droughts and with the ongoing process of climate change the water level may drop below the critical level even in the deeper basin. To **make sure that the ecologically required minimum amount of water can be made available in case of emergency** a structure enabling water to be supplied from the nearby river was also put in place.

4. To the joy of the residents, one side of the wetland habitat is specifically designed **for recreation**. A long straight lake shore will be created on the "recreational side", with regularly mowed grass. The flat slopes planned to be formed will be **safe**, because not even children will slide on those slopes into deep water; benches, piers, fire pits and information boards will also be put in place on this side of the pond.

5. By contrast, **on the biodiversity side the shoreline is irregular, zigzagging, with slopes of various gradients**. A diverse flora and fauna (reeds, sedges, floating and rooted pond weed, reptiles, amphibians) will be able to settle and live in the various sections with different physical attributes.

6. The designs also specify the hydrophilic tree species, native to the region, will be planted around

the reservoir, once the project is finished. At the same time, **the old native trees** present in the site were **spared** during the works.

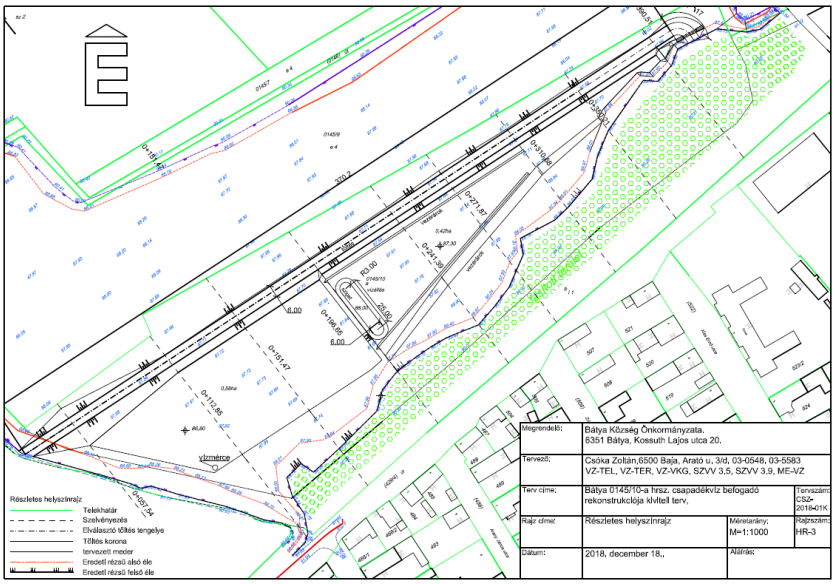


Figure*5* - An example for a cross section with a stepped embankment covered by reeds and with a slope. The cross sections are taken from the designs of the decant water reservoir of the village of Ruzsa. (Designer: Iván Balla, Ferenc Máriás)

3.2.3 Financial implications

The budget for the pilot projects – prototypes – constituting the natural water retention solutions implemented by the five municipalities in 2019 and 2020 under the LIFE-MICACC Project was worked out in the summer of 2016. At that time an amount of HUF 4-5 million was calculated for design[28] for each municipality (i.e. for each prototype), and HUF 30 million for construction[29] based on a preliminary estimate of the costs. Meanwhile, the costs of construction increased by about fifty percent, complicating physical implementation and causing delays (of about half a year) in most area.

Experience shows that the time expected to pass between the preparation of the budget and the time of construction should be taken into account in estimating costs and higher prices, expected to be in place at the time of the physical implementation of the project should be used in the calculations of the costs of construction and implementation. This may help avoid a situation where price increases in the meantime make it impossible to implement the project.

60% of the costs of the implementation of the LIFE-MICACC Project, with a total budget of about HUF 800 million, was financed by the EU LIFE Programme, while the 40% own funds were contributed by the Ministry of Interior and the partners concerned. In the form of national own funding support the Ministry of Innovation and Technology and Nyugat-Balkán Zöld Központ Nonprofit Kft. (Western Balkans Green Center Ltd.) also contributed to the successful implementation of the project.

[28]The following tasks were planned under the LIFE-MICACC Project: geodetic survey, planning of the NWRM by the designer, obtaining the water rights and environmental permits, engaging a public procurement expert.

[29] Construction (implementation) involved the following activities (with different types works required for the various pilot projects): preparatory earth works, dredging, embankment, slope forming, log dam construction, creation of habitat, removal of mud, pond creation, construction of water retention/flow control structures etc.

3.2.4 Obtaining the water rights establishment permit

Under the Hungarian regulations the procedure of obtaining a water rights establishment permit had to be conducted the implementation of each of the 5 natural water retention solutions presented above. The types and lists of the necessary permits may vary by country, therefore the Hungarian procedure is not presented in detail in this document. It must be emphasised however, that knowledge of, and compliance with, the relevant and effective statutory regulations is indispensable. It is worth gathering information about the following in advance:

- which authority/authorities is/are involved in the issuance of the required permit/permits?
- what documents will have to be submitted?
- how much time is likely to be required for the procedure to take place?
- what costs will/may be incurred?

3.2.5 Conducting a procurement/public procurement procedure

In Hungary there was a need for the selection by each municipality of a contractor for the construction of the natural water retention solutions as well as an expert for preparing the technical designs and for carrying out the technical supervisor's tasks. The justification of conducting a procurement/public procurement procedure and the applicable value limits also need to be determined on the basis of the effective and applicable statutory regulations.

3.2.6 Matters relating to execution

In regard to most of the tasks the works involved in the construction and implementation of a wetland habitat are not much different from those required for other projects customarily implemented by Hungarian municipalities. Regular supervision of the works, commissioning a good technical supervisor, representing the interests of the town or village during consultations with the contractor, are also important requirements. The above mentioned designer's site supervision is another key requirement, particularly where solutions that are not so widely used, are also included in the designs (see 3.2.2). Then there are certain specific aspects, rarely having to be taken into account elsewhere, which may significantly restrict the period of construction/implementation or may lead to delays in the works, owing to which a sufficiently long time should be scheduled for the works.

A. Time restrictions prescribed by authorities

Where the project involves any protected area, the authority issuing the water rights establishment permit involves the nature conservation authority, and also consults representatives of the directorate of the local national park, *ex officio*. If necessary, the authority restricts the time period during which the works must be carried out and/or permit certain operations to be carried out only during specific periods in order to preserve natural values. In the case of wetland habitats that are home to amphibians, earth works are usually permitted to be carried out between 15 August and 31 October. Another frequent example is site preparation involving the removal of trees, reeds or bushes, which may typically be carried out outside the nesting period, i.e. between mid-August and mid-March. The periods specified in the permit (which may be different from the above ones) must always be adhered to.

B. The weather

Works may also be heavily influenced by weather, primarily precipitation. **In rainy weather** the soil's moisture content increases, the increased weight of the earth moved during earth works pushes costs up therefore **such operations should be carried out in dry periods.**

> *"Double time should be allocated to the construction of structures and pond beds. The wet earth, too rainy or too dry weather when the irrigation canal is filled with water, all made it impossible to construct deep foundations, construct concrete structures and drove up the costs of earth works. In such circumstances it is worth waiting until conditions improve."*
> József Varga, Mayor, Rákócziújfalu

The **soil's stability** may also cause problems. For instance, in the village of Bátya the soil of a high humus and moisture content, excavated from the bottom of a former watercourse bed, had to be used for constructing an embankment around the prospective storm water reservoir. To avoid stability problems and to comply with the regulations on the protection of humus, the various fractions of the excavated soil had to be moved, and carried from place to place, multiple times.

C. Presence of protected species

Natural water retention solutions are projects that are implemented in many cases outside the built environment, or even outside the administrative boundaries of the given town or village, where there may be protected plant and animal species. These must, by all means, be protected, even when work is not taking place in a protected area. Species may have to be relocated, time restrictions may apply to the works, or some preserving technology may need to be applied. It should be noted that protected species may only be relocated in possession of permit from the nature conservation authority.

D. Information and involvement of residents

The design and construction of natural water retention solutions, particularly the earth works, are very spectacular. Photo documentation should be prepared before and during construction, and residents should be communicated with, in newsletters and social media, about the purposes and progress of the work. Putting up an information board at the premises and organising site visits for local residents, may also be highly useful. Local residents should be involved in physical implementation as well, if there is any work process in which they can be involved without the risk of accidents. Such work activities may include picking up litter, planting trees or other plants, watching birds, construction of log dams etc. These provide a good opportunity for the involvement of younger generations and for awareness raising.

3.2.7 Obtaining an operating licence

Under the rules in place in Hungary the as-is state must be assessed after the technical handover and takeover procedure following the completion of construction/implementation (in the LIFE-MICACC Project it took place within about 30 days), and an as-built design must be prepared on the basis of the assessment. The as-built design must be submitted to the permitting authority in an application for the water rights operation permit. The recommendations presented under 3.2.4 Obtaining the water rights establishment permit, apply in this case as well.

3.2.8 Assessment of the impacts of the implemented solution – monitoring

Measurements relating to the impacts of natural water retention solutions may be required for two reasons. On the one hand, the permitting authority may prescribe that measurements be taken – on a mandatory basis – in certain cases, during the procedure whereby it issues its permit, and later it may prescribe monitoring tasks as a prerequisite for operation. On the other hand, municipalities should take various measurements in order to be able to monitor its own objectives and/or make further decisions.

I. Measurements prescribed by the authority before and after the issuance of the water rights permit

The permitting authority may also prescribe certain measurements to ensure safe operation, to be taken by the municipality during both the test operation and later on during the operation of the facility, at the prescribed frequency. In case the water retention project involves or affects Natura 2000 or protected natural areas (as well), the instructions and requirements laid down in the permit issued by the nature conservation authority must likewise be taken into account.

II. Measurements taken on a voluntary basis to monitor co-benefits, and for use in decision making

In addition to the mandatory elements, other impacts – which the municipality set itself as a target to be attained when selecting the most suitable water retention solution (Chapter 2, co-benefits) – should also be monitored. In the light of the results achieved the municipality can evaluate the effectiveness of the water retention solutions in climate change adaptation, it may set up an order of preference of the various applications, collect information for the future regarding maintenance requirements and the estimated operating costs, it can make sound decisions on the replication of the solution and its use in other areas, or their integration in a system. An assessment of the associated impacts may be recommended depending on what the primary and secondary objectives of water retention were. The following is a non-exclusive list of the indicators and ratios enabling the identification of the impacts and effects of water retention on the life of the community.

1. Monitoring of incidents in which damage occurs; social and economic impacts

Monitoring changes – brought about by water retention solutions – in incidents in which damage occurs may perhaps be the most important. The information so gained is of relevance to the assessment of the effectiveness of the adaptation measure.

Measuring other positive social and economic impacts may also be of relevance, for instance where a water retention project contributes to the attainment of objectives of tourism and/or recreation as well, it is possible to keep tracks of the numbers of visitors and guest nights spent. Some parameters recommended to be monitored in regard to social and economic impacts:

- Has the number of incidents in which damage occurs (flash floods, droughts, accumulation of inland excess water, inundation of inner areas) decreased?
- Has the extent of loss and damage caused by incidents decreased?
- Has the level of groundwater come closer to the optimum? What impact(s) has this had on agriculture?
- How has the number of visitors changed? Has the number of guest nights spent in the town/village increased?
- What other ecosystem-services are being provided by the wetland habitat (e.g. in flood protection, support of rainwater management, microclimate control etc.)?

2. **Assessment of impacts on the water budget**

If the water retention solution was specifically aimed at having positive impacts on the water budget, such impacts should be measured. For instance, **surface water quality** can be easily checked by anyone visually, or by smell, or by observing fish coming to the surface to gulp air (when fish come up to the surface to "breathe", indicating high water temperature and low oxygen content). The **amount of water** can simply be tracked after putting in place a water level gauge. The existing system of wells should be used for checking the **groundwater table** and analysing the **quality** of groundwater.

- How much water is retained each year on an average?
- How has the town's or village's water balance been changing?
- Has the water budget of the region improved? Has the flow regime become more balanced?
- Does the depth of the groundwater table change less than before during droughts in the vicinity of the reservoir? How far can its impact be detected?
- Has soil erosion decreased?
- Has the alluvial load and the nutrient load of live water bodies decreased?
- Has the quality of the surface waters and groundwaters changed?

3. **Assessment of impacts on microclimate**

One of the positive impacts of wetland habitats is regulating, and reducing the fluctuations of, the local microclimate. Through evaporation they cool the air, increase the amount of dew and the water contained in the soil and air. Water bodies are slower to respond to temperature fluctuations, therefore frost damage is less frequent and the summer heat waves are more tolerable in their vicinity, which is particularly important in the case of wetland habitats in or near residential areas. These can be even measured for instance by installing conventional thermometer and hygrometers immediately next to, and at some distance from, the water body.

- How much higher is the humidity of the air next to the water body relative to a more distant point?
- How much lower is the fluctuation of the temperature? Is the temperature lower, on a hot summer day, next to the water body, than at a more distant location?
- Has the amount of dew increased near the wetland habitat?
- Have damage by frost, and ground frost, stopped to occur near the water body?

4. **Assessment of ecological impacts**

Positive impacts of the creation of any wetland habitat is the evolution of new habitats, entailing the appearance of protected amphibian, reptile, bird and fish species. Their professional monitoring is, in many cases, a costly process but that is not always necessary. Where there is a nature conservation club or association (e.g. bird watchers) in or near the community, they will be more than happy to monitor and record newly arrived species. The presence of protected species may be a reason for **bringing** the area under **local protection** (see the pilot site at Tiszatarján), which is a guarantee for the long term existence of the wetland habitat. A **list of the protected species** living in the area should be put together.

Case study: Monitoring of sediment retention at Püspökszilágy

Rainwater rushing off the arable lands in the upper catchment area washed large amounts of material into the creek near Püspökszilágy and, when flash floods, developed, even part of the village was flooded with mud. A simple monitoring system was developed to measure the amount of sediment settling in the storage basins above the log dams put in place to slow down the flow of water, and in the sediment traps. On the one hand, this provides information for the municipality

regarding the rate at which the storage basin is filling up and for how many years will it be suitable for fulfilling its function. On the other hand, it provides farmers in the upper catchment area – for whom keeping the fertile soil on their fields and stopping soil degradation is crucially important – with information. Incidentally, farmers in Hungary are under a legal obligation to protect their fields from erosion[30]. Seeing the large amount of soil washed off farmers may change their tillage practices, and, for example, adjust the direction of ploughing to the contour lines, start alternating crops in strips or plant strips of trees and shrubs between their fields to control erosion.

A simple measurement system has been put in place at Püspökszilágy. Acacia sticks of the same length were hammered into the soil to the same depth. By measuring the length sticking out of the ground they can determine whether soil is carried off the area (in which case this length increases over time) or silting up is taking place (in which case this length shortens, being buried by the deposited sediment). This makes it possible to estimate the amount of sediment retained by the log dams, as well as how quickly they will fill up, how often they will have to be cleaned and how much soil is being lost from the upper catchment area.

48 – A simple measuring system to monitor how the storage basins above the log dams installed in the erosion gully are silting up. (Photo: WWF HU.)

3.2.9 Achieving sustainable operation

Since the pilot solutions under the LIFE-MICACC Project were completed by 30 June 2020, at the time of the preparation of this Guide we have no concrete experience concerning sustainable operation.

The following are planned in relation to operation, which we also recommend to other municipalities (depending on the type of water facility or structure they are implementing in their towns or villages):

- detailed provisions must be stipulated in the local operational regulation on what tasks have to be carried out in relation to the operation of the given water facility/structure – this should be discussed with a local or an external technical expert and the regulation should be worked out or supplemented accordingly;
- the water facilities/structures/log dams put in place must be entered in the local water damage response plan (LWDRP) which should be used as the preventive tool for local protection regarding these structures (the annually revised LWDRP must be submitted to the competent water management directorate by 31 December each year);
- the state and condition of the monitoring facilities, hydraulic engineering structures and natural water retention solutions can be assessed in the framework of an annual review (with the involvement of the mayor, technical expert(s), the local civil guard and the representative of the local water management directorate) – it must be checked whether they are suitable for

[30] Sections 35-42 of Act CXXIX of 2007 on the protection of arable land, on the use of arable land with a focus on soil protection.

the performance of their original functions (e.g. a log dam for its protective function) or are in need of refurbishment: any necessary maintenance work must be carried out;

- regular monitoring activity must be carried out on a continuous basis, at least once every 6 months (to keep tracks of the deposition of mud in the case of log dams, reservoir's silting up etc.);
- weather reports and forecasts must also be continuously monitored and the necessary actions must be taken, as appropriate (e.g. in the case of water storage removal/insertion of insert planks, opening/closing gates etc.);
- the water level can be checked by reading the water level gauge, that of the groundwater can be read from the monitoring wells, at the intervals prescribed in the local operating rules;
- seasonal refurbishment works should be carried out with the involvement of local farmers and civil society organisations (anglers, hunters ...) and public sector employees – a lot more money and time can be spared by involving everybody in minor refurbishment works in the form of a community effort;
- major refurbishment/reconstruction works should be carried out with the involvement of external contractor(s) if they cannot be carried out by local ones.

4 CONTINUOUS INVOLVEMENT AND COMMUNICATION

4.1 Our experience in the LIFE-MICACC Project – Applied methods and tools

In general, communication and the provision of information took place in each of the five villages concerned in the locally customary most effective way, right from the beginning. The municipalities used their proven local communication channels (website, social media, local television, radio, newspaper), as a result of which news of the projects reached both local residents and those of nearby towns and villages. Thanks to the efforts made at raising awareness some organised planting trees, others launched drawing competitions; each municipality found ways to inform and involve the local population from the very beginning. Indeed, they managed to draw attention through the project to climate change and the need for adaptation.

4.1.1 Bátya

An abandoned clay pit was renewed outside the village of Bátya: it was turned into a pond for recreation and water retention, also functioning as a colourful habitat, highly appreciated by the local community.

Attitude, the beginning

Comments from the local "experts and professionals", as well as local opinion leaders were already invited during the preparations regarding the prospective project, and they were regularly consulted during its implementation. **Their involvement made sure that news** – including the most important details – **of the project spread among the local population**. Although **some had doubts at first, after a while most people recognised that the intended project would do good to the community; more and more people became interested and inquisitive,** waiting for the news with excitement.

Public forums were regularly organised for certain **target groups (e.g. young people, civil society organisations, agricultural entrepreneurs),** where **matters such as climate protection, the prospective project and its long term positive impacts were discussed, along with demonstrations illustrating what, why and how would be constructed in Bátya.** Also, **the whole population of the community was regularly informed about the scheduled and the already completed tasks** at public hearings.

"The pilot project was positively taken right from the very beginning. Some regarded it only as a way to tidy up a neglected area but others viewed it also as an environmental protection project. Continuous communication further improved the perception of this project." (Csaba Fekete, Mayor, Bátya)

One of the most important goals was to actually improve the quality and utilisation of the area concerned. **The area used to be a neglected piece of land where only weeds thrived** so, unfortunately, **some people even used it as an illegal waste depot. The municipality wished to prevent the reappearance of this practice by all means**, therefore it was important to communicate details of the implementation and objectives of the project to the population right from the beginning.

Concrete actions towards awareness raising

During the implementation of the project the municipality organised a tree planting event in the pilot site **involving** local **residents and the project partners.** The **700 native saplings,** matching the habitat, **were supplied by the contractor engaged to implement the project. Employees of the local nursery, the local school and civil society organisations, the municipality and members of the municipal council participated** in the tree planting event**.**

The **action mobilised the entire local community** and contributed to showing even to the youngest generation how important it is to create something that is a shared value, in tune with nature, and

49 – Members of the local civil guard help planting trees in Bátya (Photo: Bettina Hugyecz, Ministry of Interior)

50 – Even nursery school children participated in the tree planting event in the spring, in the spirit of awareness raising. (Photo: Bettina Hugyecz, Ministry of Interior)

contributes to wildlife. In this way the **participants have a sense of ownership of the area and the trees they have planted, so they will be very likely to protect and appreciate it.** Accordingly, such an action is an effective method for **strengthening commitment and bonding** in those involved.

Results

The recreational area created in the project side (benches, some covered, etc.) is an attractive option for residents because no such kind of facility has yet been available in the village. **Water retention and microclimate improvement** has not been interesting for many in the community but thanks to the project these terms **sound more and more familiar to residents**. **They have been open to the steps taken** so far in the way of awareness raising. **Those working in agriculture quickly recognised that it will be worth laying significantly more emphasis** in the future **on environmental protection and water retention.**

The tools used in Bátya:

- specifically contacting local opinion leaders, professionals and interest groups;
- holding public forms and public hearings;
- planting 700 native trees (with the involvement of the school, the nursery, civil society organisations and the municipality).

4.1.2 Püspökszilágy

A complex system was created in Püspökszilágy, capable of protecting the village and the community (by slowing the flow of water) from flash floods; less damage, more retained water and a wetland habitat with a rich flora and fauna. This is also appreciated by local residents.

"In my opinion what people appreciate the most is that the complex solution put in place can protect their residential properties and their built environment, and that it guarantees safety for those living in the village. Another benefit – besides safety – is the recreational function and a hiking place for residents and that even young people can have a good time here. The trust of local residents, their well-being and awareness raising among future generations are also very important." (Sándor Tordai, Mayor, Püspökszilágy)

51 – Large numbers of schoolchildren have visited the reservoir at Püspökszilágy. (Photo: Attila Burzi)

Community-wide interest

The community was kept informed through a variety of channels, including the **local newspaper, public forums, village days, website**.

The municipality organised several forums, including site visits, for other municipalities in the catchment area and the local microregion. These events drew wide interest.

Moreover, contact was made with the **School District Centre of Vác**, the body **maintaining the schools in the districts of Vác, Szob and Szentendre**.

The **municipality has already signed preliminary agreements with as many as 15** of the schools concerned, and **multiple camping programmes at, and visits to, the site (lasting from one to several days) have been organised with the involvement of the forest school of Püspökszilágy.** This is a very effective method because **through schoolchildren they can** also **involve parents and families living in the region.**

52 – The Mayor misses no opportunity to talk about the importance of water retention. (Photo: Attila Burzi)

This is an excellent opportunity for both awareness raising and tourism. Having seen the project the children **at home tell their families about** what they have seen in Püspökszilágy **and in many cases they even come back to the village, in organised programmes or on their own,** to see the elements of the project, as part of a day's hiking or a visit. They can **take photos of the animals and plants living in the area (habitat)** affected by the project, which is an attractive opportunity particularly among children. About 350 young people (from nursery school children to university students) have seen the pilot site so far[31].

[31] By 31 December 2020

Civil society organisations (anglers, hunters, environmentalists) are contacted and involve on a continuous basis. This is greatly facilitated by existing and new achievements in flood protection, water management and water retention, as well as the development and evolution of a highly rich flora and fauna in the area. **Farmers and primary agricultural producers** are also involved on a continuous basis; the municipality provides individual and small group programmes for them.

Walks with the Mayor

Interestingly, there are external initiatives as well, as a result of the extremely wide interest on the part of the media, not only in Hungary but also from abroad. For example, **other mayors and municipal council members have made appointments** on the basis of which the **Mayor organised walks** during which his guests visit, and familiarise themselves with, the project. The municipality takes every opportunity to transfer knowledge regarding the project as widely as possible, so that people from the same catchment area as well as other towns and villages of similar conditions can see and adopt the Püspökszilágy model. Particular emphasis is laid on making sure that the LIFE project and other related municipal projects (e.g. inland excess water, rainwater projects, road construction, reconstruction of public buildings) operate in a coordinated way, multiplying each other's positive impacts.

Future plans

The various projects under way are coordinated in the village on the basis of a **Water Protection Plan.**

Special opportunities have been created for **farmers through the utilisation of any excess water,** and the relevant stakeholders are provided with support to make use of the new opportunities (**bee pasture, irrigation, organic farming**) brought about by **changes in the habitat**. Another **future plan** is to make the pilot project fully accessible for the general public by constructing a nature trail starting from the springs and ending after the bank-side reservoir, to make sure that people who are interested in the site can see and learn about the operation of the entire project in its natural environment.

The municipality wishes to **put up** an **observation tower** in the near future to make it possible for people to have an even better view of animals in the area and thus offer an even more colourful programme for children and other interested people.

The tools used in Püspökszilágy:

- making contacts with schools in the region;
- organising camping and hiking programmes (showing the pilot site);
- organisation of walks with the Mayor;
- forums and discussions with groups of stakeholders;
- creating a nature trail.

4.1.3 Rákócziújfalu

Water (including inland excess water) wasted so far is now discharged into a lower-lying pond through an inland excess water drainage canal. The pond and its environment is a community meeting point for residents.

"It was a pleasant surprise to me when in the local school we asked children to show in drawings how they envisage the pond to be created under the project and we managed to make them so excited about it that they submitted a lot of colourful and creative entries. Some of the ideas reflected by the drawings have indeed been realised, so I believe they – and hopefully not only the children – will regard the pond in the village even more to be their own." (József Varga, Mayor,

Rákócziújfalu)

How residents' interest evolved

Initially, residents showed little interest in climate change and the project, but as the municipality was making progress in implementing it, most people appeared to be more and more interested. **The municipality wrote and reported about the pond being constructed, on various platforms and in its own institutions (crèche, nursery, primary school)**, they distributed a flyer about the project and they were also active on the social media platforms. The aim of providing residents with information was to raise awareness, promote climate adaptation and sensitise the people. Experience shows that it was highly effective when **the Mayor, public officials and members of the municipal council, the civil guard and the anglers' association personally informed residents about the objective of the project and its expected benefits:** it will afford safety, retain inland excess water and surplus rainwater, provide an additional watering place for wildlife (a benefit for the local hunters' association) etc. Indeed, the municipality **organised visits for residents as well as interested leaders of nearby villages at the project site.** Through the **drawing competition** organised in the local primary school, with the rainwater reservoir pond as the focal theme, to which more than 80 entries were submitted, the municipality managed to actively involve even a younger generation in the thinking process and in creating a future vision.

53 – The prizewinning works of the competitors in the first three positions. (Photo: Gabriella Szabó, Ministry of Interior)

Future encouragement of the population

To encourage residents to retain and utilise rainwater the municipality is planning to take the following actions in the near future, in coordination with professionals of the water management authority. The street front rainwater gutters will be connected to the rainwater canal to be constructed under TSDOP[32] project, which will be connected to the rainwater reservoir. **Rainwater collected from the roofs of backyard buildings will be used for irrigation in household gardens or infiltrated into the ground.**

Adaptation – at the level of the community and residents alike – has become a top priority, thanks to the project.

Tools used in Rákócziújfalu:

- provision of information in person, on the project's objectives and impacts;
- organisation of visits to the pilot site;
- organisation of drawing contest at the local school.

[32] TOP-2.1.3-16-JNI-2019-00003 "Rainwater drainage network construction Phase 1 Rákócziújfalu" project.

4.1.4 Ruzsa

Every drop of water is becoming more and more valuable in the village on the sand ridge. The residents of Ruzsa value and appreciate everything they are given by the pond: improving microclimate, water supply for the soil, community space. A place where one likes visiting, sitting on the benches, having a chat with others or even giving it a try on the BMX track next to the pond.

Mixed feelings at the beginning

"It is very hard to judge whether the attitude of the residents of the village has changed with the LIFE-MICACC Project. I would like it that way but it may take quite some time. I am sure that the changes in my attitude are reflected by my work now, by the importance I attach to the retention and wise use of water. All of us have drawn lessons and gained experiences that we can use in our day-to-day work." (Gizella Sánta, Mayor, Ruzsa)

The local community responded with great excitement and some concerns to the news of the pilot project. On the one hand, because **the majority would have liked a complex solution to water loss**, on the other hand, because **they were afraid of the ponds' potential negative impacts** (e.g. a stale smell in the air, more mosquitoes, children falling in the water). Thanks to the long time it took to implement the project **these concerns vanished as the Mayor, the designer and the contractor answered all questions and proposed solutions acceptable for all. The project elements that have been completed are highly popular and actively used by many.** Since much of the pilot project is usable and enjoyable for people in their daily lives, it did not take long before they **accepted and now regard the areas concerned as their own**.

Direct provision of information on implementation

Local residents were kept informed through all possible channels (website, social media page, local and county newspapers, regional television) and a presentation was delivered at the **general meeting of the local Farmers' Association and at a public hearing**. The municipality **showed the works in a street forum** to those to be directly affected.

Since physically implemented project elements are more quickly noticed by residents, in the first round they were informed about details of the investment project. With the **progress of implementation more and more awareness raising elements were added to the communication and the municipality also integrated information about climate change.** As the Mayor said, her personal view – as the leader of the community – also changed and she grew highly committed to water, environmental protection and climate protection. And this will probably affect the municipality's future development projects as well.

54 – The Mayor at a street forum with interested residents. (Photo: Szabolcs Fodor)

Tools used in Ruzsa:

- presentations on the project (for different stakeholder groups, right from the beginning);
- public hearing;
- organisation of street forums.

4.1.5 Tiszatarján

In addition to creating a more favourable environment for buffaloes and grey cattle, while increasing the area's floodwater holding capacity, local residents of Tiszatarján also like to take a walk around the pond; indeed, cyclists and pedestrian tourists also come here from all over Hungary. Residents are proud to show the way to the Buffalo nature trail.

Communication

"We have long been committed to environmental protection and to the protection of wildlife in the floodplain. We are really happy to see how local residents and people from nearby villages, as well as tourists, like and visit the area. The pilot site was even used as the venue of a series of wedding photos. Positive feedback from people confirmed for us that it is worth investing time, money and energy in protecting the environment and preserving floodplain wildlife." (Mrs. Lajos Bögre, Mayor, Tiszatarján).

The municipality distributed the flyers with information on the project and **held personal consultations** with the various stakeholder groups (e.g. farmers, mayors of nearby towns and villages), **on the project and the effective local means of responding to climate change challenges**. The virtual space – the municipality's website – became the key venue for sharing information with the community in 2020, primarily as a consequence of the pandemic.

Residents took the project well, they are very proud of Tiszatarján being able to join the tourism industry based on Lake Tisza, with its nature trail. Thanks to the provision of information, and involvement, **residents understand what water retention means and the reason why it is important to create a new water retention facility** to retain water after floods as long as possible in lower-lying areas.

Involvement, awareness raising

During the closure of schools in the spring of 2020 schools organised physical education classes for lots of schoolchildren in the pilot project site, on which a lot of positive feedback was received from both children and parents. A **summer camp was organised for children** in the Tiszatarján Community Centre in the summer of 2020, where they were shorn the pilot project site with the help of demonstration tools and presentations and then they took a visit to the solution in place.

The tools used in Tiszatarján:

- distribution of flyers on the project among residents;
- involvement of the local school – physical education classes at the pilot site;
- organisation of summer camp for children.

55 – The Tiszatarján pilot site. (Photo: Filmever Stúdió)

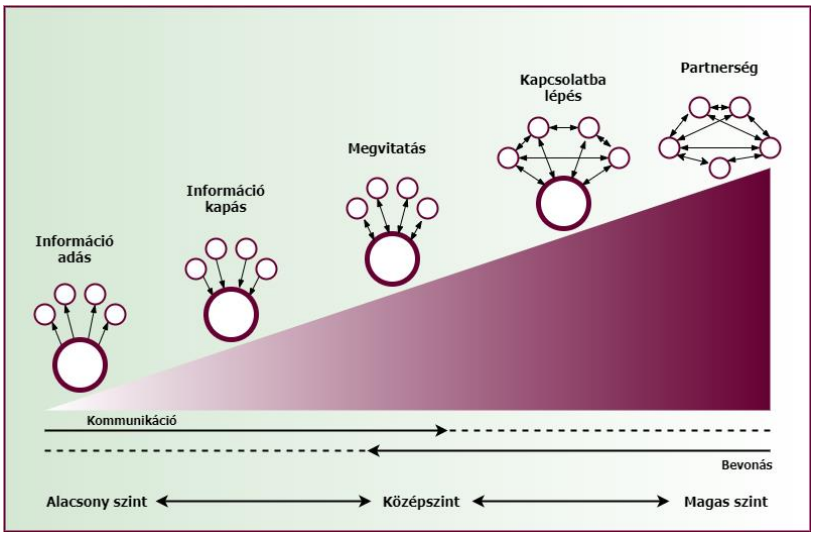
4.2 Why is it important to involve stakeholders? What do we mean by stakeholder and involvement?

Stakeholder(s): any organisation, institution and person, including the public, the private and the civil society sectors, having to do with, affected by or associated with the given strategy, programme or project, directly or indirectly, positively or negatively or as having an impact or being impacted.

Involvement: citizens and stakeholders contributing, with their knowledge, power or resources, by being interested, to the performance/implementation of a given task/project, actively shaping local development by contributing their knowledge and/or opinion regarding a given theme. The level of the involvement of residents may range from mere information, to consultation, to actual cooperation between residents and the municipality.

The sustainable development of a given town or village can be driven by ensuring locally implemented solutions and developments simultaneously satisfying social, economic and environmental needs and demands, creating a mutually beneficial (win-win) situation for those concerned (stakeholders). This requires continuous communication and the involvement of local groups having an interest particularly in the given project, because decisions taken at the local level have direct impacts on the day-to-day lives of local residents, businesses and employees. Those involved make a contribution and feel more of an owner of the given project, i.e. they have a high degree of personal involvement.

The support and participation of the various stakeholder groups have a profound impact on the life of the town or village concerned and may substantially influence the acceptance, success and sustainability of various development projects and local solutions. They may, however, have equally profound negative impacts as well, if they resist or object to the proposed development because of inadequate information, lack of possibilities for participation or even assumed threats to their individual interests. It is important that community leaders should view the variety of the opinions and claims of stakeholders as an opportunity which can generate value for the community if the various stakeholders get to be involved in the local decision making processes through communication and involvement processes. Communication with local participants and groups can enable viewpoints and opinions to be taken into account in making various local decisions which will contribute to the wide acceptance of the decisions thereby strengthening confidence between the community and its leaders, their mutual recognition and support.



56 – Process and levels of involvement. (Prepared on the basis of: www.localmanagement.eu/index.php/cdp:local_authorities_involvement_and_communication:hu#ch_2)

The principles that should underlie involvement.

- Involvement should be real – involvement processes should not take place for appearances' sake.
- Involvement should be started at the inception of the process, rather than calling for opinions on a ready-made concept or plan.
- All relevant pieces of information should be shared and stakeholders should be made aware of their respective roles in the process. Possibilities for factoring in the various stakeholders' requirements must be clarified, along with the terms and conditions that cannot be deviated from (e.g. budget, project site).
- Time should be provided for stakeholders to form their opinions, to the extent possible, because understanding, discussing and approximating different considerations is a time-consuming process.
- A smaller, mobilisable, group of stakeholders (opinion leaders) should be involved first. Upon encountering problematic aspects, the group may be increased.
- The results should be laid down in wiring and disclosed to the public.
- Involvement should be a continuous practice, rather than a campaign.[33]

Accordingly, involvement plays a key role in community acceptance, in the planning of projects and their smooth and effective implementation particularly in the case of actions such as local adaptation to climate change on the basis of natural water retention solutions, that are not very well known and accepted yet in Hungary (and elsewhere in Central and East Europe).

We tend to underestimate the benefits of the information of local stakeholders. Although communication takes continuous extra work, it is worth investing the energy because it may return many times over later on (e.g. in community building contributing to the development of the town or village, or in the form of a new use of an abandoned area improving the overall picture of the town or village).

4.3 Recommended process of stakeholder involvement – Who should be involved?[34]

Municipalities today have to operate successfully in a complex environment. If a town or village is to be successful in its existing or future environment, the municipality leaders must take into account the existence and role(s) of the stakeholders. Any and all organisations have stakeholders, i.e. groups and individuals who have a stake in the accomplishment of the community's goals. The identification and analysis of interest groups is key because their expectations and goals may both promote or impede the municipality's endeavours. Even the most noble endeavours can fail if those of the relevant interest groups are not analysed and "managed" (by channelling into our own development activity and/or by alleviating or fending off the impeding factors).

Stakeholder analysis is a way of thinking that may help in a given situation or in relation to a problem or in a phase of the changes intended to be made:[35]

[33] Emese Farkas-Gasparics Emese – Róza Számadó (2015): A településmenedzsment átalakulása a működési keretek tükrében. (*Transformation of municipal management in the light of the operating framework*) Polgári Szemle, Vol. 11. Ed. 1–3 205., http://polgariszemle.hu/archivum/94-2015-junius-11-evfolyam-1-3-szam/allamtudomany-jogtudomany/656-a-telepuelesmenedzsment-atalakulasa-a-mukoedesi-keretek-tuekreben (available only in Hungarian)

[34] Source: Róza Számadó (2017): Inkluzív önkormányzat építés (Inclusive municipality building), and Róza Számadó ed.. (2017): Inclusive municipality planning (available only in Hungarian)

- ✓ in order to identify the stakeholders, their objectives and motives;
- ✓ their relation;
- ✓ the impact the given situation/problem/change has on them as individuals (their fate, livelihood/existence etc.);
- ✓ their attitude to the given situation/problem/change;
- ✓ the influence or impact they have on the given situation/problem/change;
- ✓ to what extent/how can we influence them.

1. step	Identification of the stakeholders
2. step	Interests, motives and expectations of the stakeholders
3. step	Stakeholders' relation, behaviour, influencing capability and influenceability
4. step	Preparation of matrix
5. step	Identification of tasks regarding the various stakeholders
6. step	Ranking, forming groups of stakeholders

1. step – Identification of stakeholders

The stakeholder involved in the given situation should be taken into account in relation to the given problem, project, development or strategy! (Written in a summary table, on a piece of paper or on post-its.)

Who can be stakeholders in the case of a municipal government? The population, a specific group of residents, businesses, neighbouring town or village, government office, member of parliament, a body, employees of an office, the school's teachers and students, pensioners, civil society organisations, environmentalists, experts etc.

2. step – Stakeholders' interests

It is possible and necessary to explore and identify what motivates the various stakeholders to act, what they can be influenced with or what their relation to the project can be consolidated or modified. This requires knowledge of the actual motives and expectations because it is only with this in mind that we can respond to stakeholders' expectations.
Stakeholders can be categorised in advance in terms of their decision making criteria, their objectives and expectations; this helps us keep them informed and consult and cooperate with them to make sure that the most accepted solution gets to be implemented.
Think over the various stakeholders' expectations and interests regarding the given situation! If you think it is necessary, make a brief interview/have a chat with the community's "key figures"!

3. step – Stakeholders relation

It is important to know the various stakeholders in terms of their involvement, their relation to the given situation and their potential influence (power), as well as how we can influence their relation to the situation.

List the interests of the various stakeholder groups, the degrees of their involvement, the levels of their support and their influencing capabilities. This is what the table that can be downloaded from the project's website is intended to help.[36]

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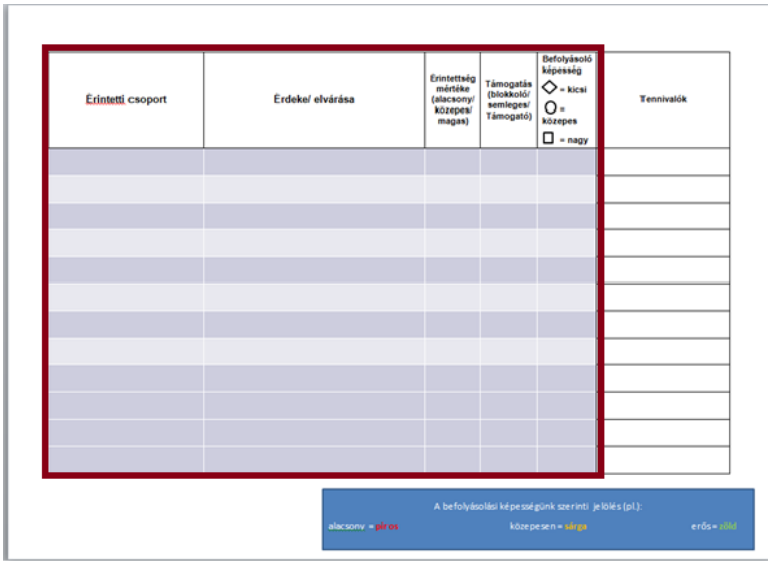
[35] Róza Számadó: Inclusive municipality – planning, pp. 29-33 (available only in Hungarian)
[36] Annex regarding the identification of stakeholders:
https://vizmegtartomegoldasok.bm.hu/storage/dokumentumok/Stakeholder%20involvement%20table.pdf
Source: Róza Számadó's presentation entitled "Stakeholder elemzés, stakeholder-menedzsment" (*Stakeholder*



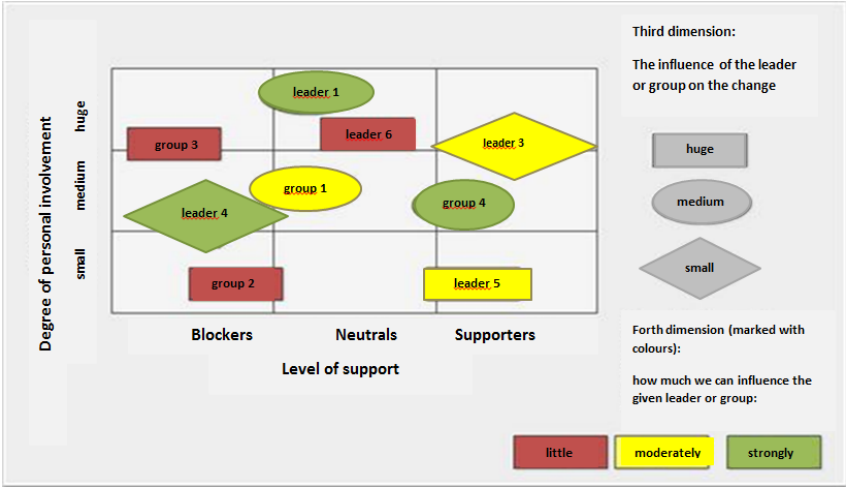
57 – Stakeholders' relation

4. step – Preparation of a matrix

The analysis of the stakeholders can be illustrated in four dimensions:

(1) Personal involvement (vertical axis)
(2) Degree of support (horizontal axis)
(3) The stakeholder's influence on the changes to be triggered by the project (geometric shapes)
Influencing capability: ◇ = low; ○ = medium; □ = high
(4) Our own capability to influence the group concerned (colours)

The dimensions are presented in a matrix, where dimensions 1 and 2 are sides of the matrix, dimensions 3 and 4 are illustrated with geometric shapes and colours.



58 – The frame of the matrix

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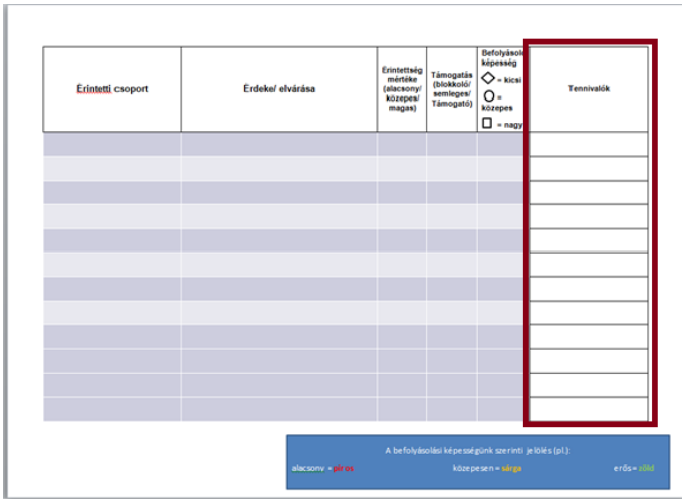
analysis, stakeholder management). The figure has been prepared on the basis of the publication entitled Inkluzív önkormányzati tervezés (*Inclusive municipal planning*) (Edited by: Róza Számadó, Dialóg Campus, Budapest, 2018.)

Place the stakeholders in the matrix!

The following should be examined before moving on:

- do the majority of the stakeholders support the proposed solution/development?
- what interventions do we need to execute?
- where are the so-called critical points?

5. step – Setting out the tasks



Specify the necessity of, and way of executing, the interventions and tasks! (For instance, by a face to face meeting, organisation of a forum, proposing a discussion with the stakeholder group.) This can be entered in the last "To do" column of the table downloaded in Step 3.

59 – Identification of the tasks

6. step – Ranking the stakeholders

Assign stakeholders to groups A–D as per the table below! (You will find the recommended action/mode of treatment for the various types.)

	Their interests are negligible for us	**The relevant interests are important for us**
They have no power to assert their interests	**AUDIENCE (A)** They need minimum effort, but also have to be watched.	**EXTRAS (B)** Relations with them should be improved, they should be informed and their "good intention" should be secured
They have substantial power to enforce their interests	**GUEST ARTISTS (C)** Relations with them should be cultivated/improved, their interests should be taken into account. Their views should be influenced to the extent possible, their powers to convince others should be used. Their interests should be taken into account as much as possible.	**KEY FIGURES (D)** We should try and influence their views to the extent we can and take into account their interest to the extent possible.

4.4 Shaping forms of communication – How to communicate with the audience?

Based on the evaluation and ranking of the stakeholders we can develop the system and the content of communicating with them as well as the channels to be used in the process.

A) Messages for the various ranked stakeholder categories group (E.g. "D" – Key figure)

Situation and stakeholder	Their interest/expectation	Message	Supplementation, note (e.g.. recommended revision time)
Creation of natural lake for water retention – local farmers	The water retained should mitigate risks of droughts, floods and inland excess water, reducing loss of/damage to yields.	The new lake will be suitable for alleviating negative impacts by extreme weather conditions: it will retain extra rainwater in the location which will mitigate the risks of droughts by replenishing groundwater reserves.	At least one piece of news should appear in the local paper/television during the implementation of the project. The situation should be reviewed once every six months with the stakeholders (e.g. in a forum), along with the message of our communication.
Construction of log dams on a side-branch of the creek flowing through the village – residents (particularly owners of properties affected by the floods)	The creek should not overflow its banks during the frequent flash floods in the village, residential properties and fields should not be flooded.	The log dams slow down the flow of the water (and sediment) during flash floods, flatten flood peaks helping the community avoid inundation. In addition to being quick to build, it is also a relatively inexpensive solution (especially if made from locally grown logs).	Information should be provided through the media most read/listened to by local residents: local newspaper, radio, television, website. People should be enabled to ask questions and be involved in discussions office hours, public hearings/forums.

B) Development of communication matrix per stakeholder group

Organisations that are really effective in the involvement of those concerned regularly communicate with their stakeholders through relevant channels, developing and delivering targeted messages to them (in terms of the stakeholders' objectives, motives and expectations).
Based on the following table it is possible to work out the means/channels of communication through which and the frequency at which our stakeholders are to be provided with information. (The frequency should also be indicated in the "Stakeholders" field: once/during a given period/at a certain frequency.)

	Communication channel							
Stakeholders	Notice board	Local newspaper	Flyer	Personal consultation	E-mail	Mayor visits them	Conference	etc.
Pensioners	X	X	X	X		X		
Frequency	monthly	monthly	once a year	monthly		on pensioners' day		

C) Putting together a communication plan

The most important pieces of information regarding communication and involvement can be summed up in a communication plan in relation to the situation/project/prospective development:

- overall strategic and communication goals – what we wish to achieve (a brief summary of the planned project);
- communication principles underlying the communication activity;
- identification of target groups/stakeholders – the audience (with the help of the above techniques);
- formulating the message – planned communication and its tools;

- scheduling the communication activity, brief description of each phase;
- identification of the concrete tasks relating to communication and designation of responsible persons/units;
- assessment/backtesting of effectiveness and efficiency of the communication;
- working out and indicating preliminary cost estimate.

4.5 Recommendations

Addressing, involving and informing those concerned/the stakeholders **must be a continuous process during the entire term/period of the given project/development.** Local residents are usually interested in what, and for what purpose, is being put in place in their town or village, and how it will affect their lives. Therefore, **local residents and stakeholders should,** by all means, **be kept informed about progress being made right from the beginning**.

The following is a summary of our recommendations regarding involvement and communication.

We recommend the following:

- **Prepare a brief, easy to understand (summary) material on the development/project!**

What is the project about? What can it be used for? What impacts will it have on the town or village? What advantages/benefits will it yield? Who is it good for?

- **Think about and identify the key actors!**

Who should be consulted in the first and then in the second round (stakeholder groups)? Who are the main target audience? Who should be contacted with what message?

- **Consider and determine the way and tools of communication/provision of information!**

What method(s) will you use? What will you communicate with (toolkit)? When/how frequently (schedule)?

Recommendation concerning communication tools:

- **provision of information (right from the beginning) on the prospective project in the locally customary way (notice board, local television, radio, local newspaper, website, social media etc.);**
- **contacting local opinion leaders, professionals and specific interest groups in a targeted way (to make the project even more well-founded);**
- **forum/public hearing/street forum (where the municipality can answer questions);**
- **brainstorming (an efficient method for integrating opinions);**
- **active involvement of local residents through various programmes (e.g. planting trees, drawing competition);**
- **making contacts, and cooperation, with schools in the region;**
- **organising site visits (for children, teachers, mayors of nearby communities, local farmers, interested professionals/experts);**
- **organisation of summer camp;**
- **creation of nature trail (putting up information boards).**

Involvement, addressing people/stakeholders, listening to opinions can **generate interest and trust in members of the local community**. Moreover, these help raise awareness that developing the town or village is not only a shared cause but also a shared responsibility. Involvement of the stakeholder groups in the process of **joint thinking about** the future of the community **strengthens commitment**, capability to act and will to act, **among local residents.**

The solution we recommend is **two-way communication based on deliberate and proactive involvement and dialogue**, for the tools and methods of which we showed ideas and guidance for municipalities in the above chapters.

GLOSSARY OF TERMS

Floodplain: an area along a river that may be flooded when the flood protection embankment fails.

Floodway: the area between the edge of the riverbank and the flood protection embankment, or high riverbank (that part of the riverbank which is higher than the highest flood level).

Protected floodplain: part of the floodplain, protected by flood protection embankments from being inundated.

Ecosystem-service: the goods and services received by humankind from wildlife, including pollination, biological pest control, foodstuffs, substances of curative effects, air and water purification, climate control, improvement of our mental health etc.

Green infrastructure: a strategically designed network of natural and semi-natural as well as other areas covered by vegetation and fulfilling ecological functions, created and managed so that they provide a wide variety of ecosystem-services. Green infrastructure supplements or, in some cases, fully replaces grey infrastructure elements (canals, buildings, embankments, roads etc.).

Blue infrastructure: blue infrastructure is part of green infrastructure but its elements are specifically water bodies: canals, channels, rivers, floodplains, other wetland habitats.

Grey infrastructure: in a broader sense grey infrastructure includes all infrastructure elements designed and created by man, made not from natural materials but mainly steel and concrete, such as, for instance, roads, conduits etc. In a narrow sense: in water management it means elements that are systems requiring major investment projects to be put in place, required for centralised water management. For instance: irrigation systems, large water dams, flood protection embankment, pump stations.

Rainwater management system: the temporary or long term storage of rainwater is becoming a more and more important consideration under today's extreme weather conditions. The amount of water from rainstorms and heavy downpours, exceeding the capacity of existing rainwater drainage systems, and short and long periods without natural rainwater supply point to the need for the management of rainwater. A complex rainwater drainage system takes care of the problems of the management of the available water in terms of quantity and quality alike.

Habitat reconstruction: activity deliberately changing the characteristics of a given area in order to create an ecosystem that is similar to the original native ecosystem. The primary aim of habitat reconstruction is to increase the size of natural habitats, create natural ecological networks and, ultimately, to preserve biodiversity.

Storm water reservoir: a reservoir constructed in or next to a watercourse to reduce peak water discharge rates and water levels brought about by flood waves and to temporarily retain water, a protective or drainage system put in place to reduce the load on water management facilities inside towns or villages.

Open canal with dual functions: a canal for carrying inland excess water as well as water for irrigation. Some canals are equally suitable for carrying water for irrigation and drain excess water, thanks to their geographical location and design.

Non-inversion tillage: the essence is that ploughing is made redundant by the use of various seed drills and varying crops, thereby helping the preservation of the high quality, and the humus content, of soils in the long term and improving soils' water management characteristics.

Soil protection with cover crops: sowing the seeds of cover crops in late summer or in the autumn in fields that would be too exposed without such vegetation to erosion by wind and water during the winter. Growing cover crops increases the soil's organic matter and (if papilionaceous plants are used) nitrogen content and improves its structure as well. The use of crop residues for covering the soil, and later their working into the soil, may be just as effective as a means of increasing the soil's organic matter content.

Heat island effect: A heat island comes about where the darker paved surfaces, concrete structures and buildings in densely built-up areas, as well as the ambient air, become extremely hot in the summer, raising the local temperature by multiple degrees centigrade in comparison with the temperature in nearby rural areas.

RELEVANT SOURCES

1. **English language literature:**

Engineering with Nature – An Atlas. A collection of nature-based engineering solutions put together by the United States Army Corps of Engineering. The publication contains a variety of good examples that can be used in Hungary as well, clearly demonstrating how nature-based solutions are becoming increasingly widely used all over the world. For more information visit: https://ewn.el.erdc.dren.mil/atlas.html

A practical guide to support the selection, design and implementation of Natural Water Retention Measures in Europe (2014). Guide prepared from material available at www.nwrm.eu. A Hungarian translation is available but it has not been proofread, therefore use of the English is recommended. Available here: http://nwrm.eu/implementing-nwrm/practical-guide

A website with exhaustive materials on water drainage systems that can be used in built environments. Applicable good practices, technology descriptions, guides: www.susdrain.org/

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