# D.T4.3.2 NATIONAL ACTION PLAN

HUNGARY

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## GENERAL INFORMATION

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## INTRODUCTION

This present document is a national action plan drafted to help the integration of Managed Aquifer Recharge (MAR) solutions into the national water resource management schemes, strategic policy documents, water management legislation or other regulations. The aim of this document is to compile a detailed, comprehensive and easy-to-follow Action Plan to be presented to the relevant decision-makers.

This national action plan proposes how, when, who and with which resources MAR can be integrated into Hungarian water resource management. Therefore, the Action Plan provides proposals and defines concrete actions for decision makers to facilitate the application of MAR systems. The Action Plan also describes the institutional settings and financial/business models necessary for the operation of MAR interventions.

## List of Abbrevations

| | |
|---|---|
| **MAR** | Managed Aquifer Recharge |
| **PPs** | Project Partners |
| **TGs** | Target Groups |
| **WFD** | Water Framework Directive |
| **EIS** | Environmental Impact Assessment |
| **CE** | Central Europe |
| **NGO** | Non-Governmental Organisation |
| **AM** | Ministry of Agriculture |
| **SZTFH** | Supervisory Authority of Regulatory Affairs |
| **OVF** | General Directorate of Water Management |
| **BM** | Ministry of the Interior |
| **ITM** | Ministry of Innovation and Technology |
| **CSSG** | Cross-sectoral stakeholder groups |
| **IAH** | International Association of Hydrogeologists |
| **FAVA** | Founding for Groundwater |

# 1. Background and approach of Managed Aquifer Recharge scheme and its adoption and/or introduction into national/regional level strategies, water management plans

Climate change and future increasing water needs present new challenges in water management. The potential and predicted effects of climate change will cause shortage of rainfall in some parts of the Central European region, whereas there will be an increase in rainfall in other areas (IPCC, 2022; ITM, 2020). An extreme temporal and spatial distribution of precipitation will be more common. Local, short-term, high intensity precipitation events can cause drastic changes in water recharge conditions. The collection of surface water surplus during such rainy periods and its storage in groundwater aquifers, followed by its utilization during increasingly frequent and prolonged periods of water scarcity, is of strategic importance for water management (DEEPWATER-CE (2021d)).

Challenges caused by growing and globally experienced water scarcity must be dealt with by risk-based adaptive strategies. Alternative solutions enhance our flexibility and resilience, in which Managed Aquifer Recharge (MAR) methods and technologies can play important role.

Managed Aquifer Recharge (MAR) refers to a suite of methods that are increasingly being used to maintain, enhance, and secure the water balance and quality of groundwater systems under stress. These methods apply processes for the increasing recharge by which excess surface water is intentionally directed into the subsurface. This can be done by several different technologies in order to replenish an aquifer and store water in suitable aquifers. MAR techniques offer promising solutions for water management, also with regard to tackling future climate change impacts (Casanova et al., 2016; Dillon et al., 2019; Dillon, 2005; Sprenger et al., 2017). This method of water management has already been applied in many places (Dillon et al., 2019; DEEPWATER-CE(2021d)).

## Overview of MAR applications

MAR interventions can be relevant in sustaining and augmenting groundwater quality, quantity and also in environmental management (Grützmacher and Kumar, 2012; DEEPWATER-CE (2019a)).

Water quality applications are aimed:

- to improve water quality in degraded aquifers (e.g. nutrient reduction from agricultural pollution, prevention of seawater intrusions), reducing the concentration of geogenic pollutants like fluoride or arsenic
- to reduce effort for water treatment (e.g. making use of natural purification processes, such as riverbank filtration).

Water quantity applications are aimed:

- to store water in aquifers for future use (e.g. water supply);
- to increase groundwater levels in overexploited aquifers.

Environmental management applications are:

- to prevent storm runoff and soil erosion;
- to preserve environmental flows in rivers and streams;
- to mitigate floods and flood damage;

- to control seawater intrusions;
- to reduce land subsidence;
- to provide hydraulic control of contaminant plumes.
- to increase groundwater levels to maintain or improve the status of groundwater dependent terrestrial ecosystems.

The design of an appropriate MAR system can take place in several ways, depending on the geographical characteristics of the location, the type of water available for recharge, the method of recharge, the type of water treatment system and the utilisation of recovered water (Figure 1). Several types of potential and installed MAR systems are reported in the literature (Dillon et al., 2009).

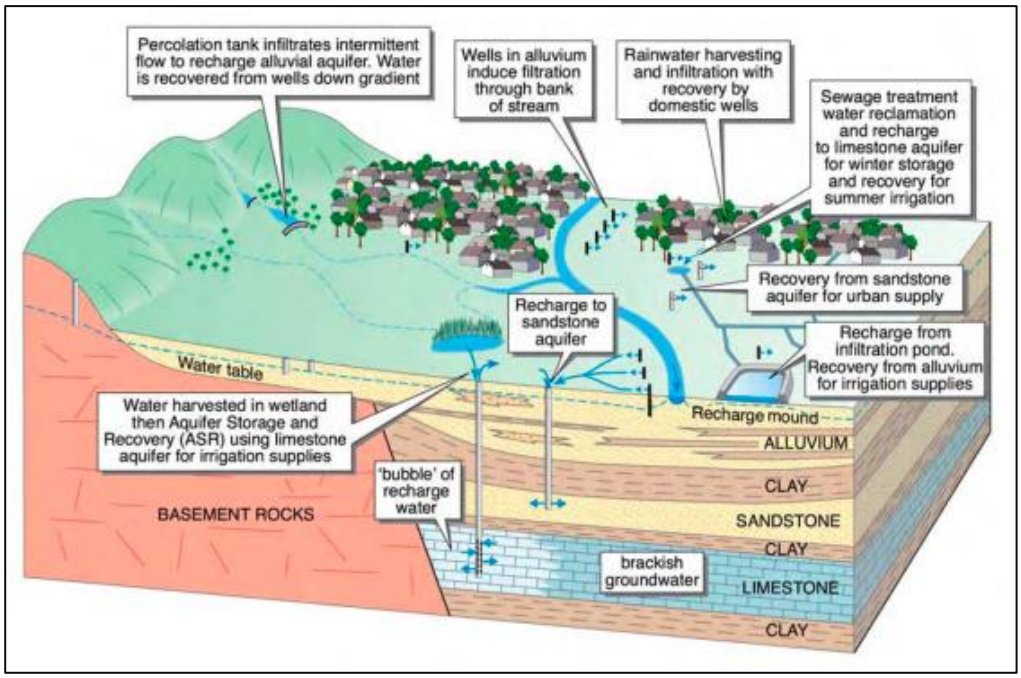


**Figure 1:** Illustration of MAR applications as a function of geographical, geological and hydrogeological conditions (Dillon et al., 2009)

MAR applications can be grouped into five types describing several similar engineering techniques (Table 1).

**Table 1:** Classification of MAR techniques (IGRAC, 2007)

| | Main MAR methods | Specific MAR methods |
|---|---|---|
| **Techniques referring primarily to water infiltrated** | Spreading methods | Infiltration ponds |
| | | Flooding |
| | | Ditches and furrows |
| | | Excess irrigation |
| | Induced bank filtration | River/lake bank Infiltration |
| | | Dune filtration |
| | Well, shaft and borehole recharge | Aquifer Storage and Recovery (ASR) |
| | | Aquifer Storage, Transfer and Recovery (ASTR) |
| | | Shallow well/shaft/pit Infiltration |
| **Techniques referring primarily to intercepting water** | In-channel modifications | Recharge dams |
| | | Subsurface dams |
| | | Sand dams |
| | | Channel spreading |
| | Runoff harvesting | Rooftop rainwater harvesting |
| | | Barriers and bounds |
| | | Trenches |

The first reported MAR site in Europe was in Glasgow, UK, which was the first bank filtration system (Ray et al., 2003). The idea spread rapidly to continental Europe and it was soon adopted by cities in the Netherlands, Belgium, Sweden, France, Austria and Germany.

Similar to other cities located on the bank of River Danube (Vienna, Bratislava, and Belgrade) in Hungary Budapest was also among the first cities to use bank filtration system for drinking water production by the Kossuth square water production utility (Csernyánszky és Várszegi 1993).

The progressing industrialization in the 19th century and growing population in European cities, then later increase in irrigation water use presented the water suppliers with new challenges which lead the wide spreading of MAR technologies in the XX. century throughout Europe.

In the beginning, the use of bank filtration systems and infiltration ponds were common (Sprenger et al., 2017). The last 60 years has seen unprecedented groundwater extraction, and resulting overexploitation, together with the development of new water treatment technologies led to the advancement of MAR (Dillon et al., 2019).

## Groundwater and groundwater management practices in Hungary

In Hungary the principle aim of groundwater abstraction is to provide drinking water supply. In addition, groundwater is abstracted for industrial, agricultural (irrigation and animal-husbandry), spa, balneology, energy and other purposes. The total protected resources within drinking water protection zones are around 3 million $m^3$/day based on 2018 data (3rd RBMP, 2021), and the amount of the abstracted groundwater is around 60 % of the total protected resources.

In Hungary, the total annual surface water abstraction is 4033 million $m^3$/y in 2018 (3rd RBMP, 2021). About 78% of this amount is abstracted for energy purpose; the rest is used for irrigation, communal or industrial utilization, and fishery or recreation purpose.

Aim of groundwater abstractions and their rough distribution between the different sectors (based on the yearly average values for the 2013-2018 time interval in %of the abstracted amount) is according to the followings: drinking water 74%, industrial water 6%, irrigation 2%, spa, balneology 6% and other 1%. It is important to mention, that 95 % of drinking water is derived from groundwater in Hungary.

## Dominant types of aquifers

In Hungary, drinking water sources are mainly supplied from groundwater stored either in the porous Pleistocene-Holocene or Upper Pannonian formations, however older carbonate formations have a key role, as well. These confined porous aquifers are the most widespread for groundwater supply and the largest hydraulically interrelated body groups of groundwater in Hungary. The maximum depth suitable for groundwater (especially drinking water) extraction is typically 400 m in the Great Hungarian Plain, because, due to the high geothermal gradient, under this depth water temperature exceeds 30 °C which is less suitable for drinking water supply (or even for industrial and agricultural usage).

Fractured and karstified limestone and dolomite aquifers are regional drinking water aquifers, as well. These form major karst aquifers in the Transdanubian Range, where the thick Mesozoic sequence consists of mainly Triassic limestone and dolomite rocks. They are in close hydraulic relationship with the overlying younger, mostly Eocene or Cretaceous limestones. Karst drinking water aquifers can also be found in the Mecsek and Villány Mts., Aggtelek Karst as well as in the Bükk Mts. In other mountainous areas the aquifers are dominantly formed by fractured or regionally fractured porous rocks. These aquifers are generally poor, considering their water supply potential. In the margins of mountains, in alluvial sediments or in the upper zones of the thick porous basin fill sediment series, shallow porous layers act as good aquifers. They are exploited mainly for agricultural purposes, but at some special places they supply drinking water. These aquifers are vulnerable to the impact of the climate change and pollution.

Bank-filtered drinking water supplies, where more than 50% of the produced water originates from the connected surface water body while the rest from the groundwater, are important in drinking water supplies in Hungary. All the future perspective drinking water reserves are delineated in aquifers with potential bank-filtration possibility.

## Quantitative and chemical status of groundwater bodies (according to River Basin Management Plans and Water Framework Directive classification)

The status of groundwater bodies in Hungary is characterized according to the 3rd National River Basin Management Plan (Draft version, 2021). According to the document one third of groundwater bodies are in poor condition. Most of these are partially the shallow cold groundwater bodies, which have weaker status both from qualitative and quantitative point of view. 43 of the 185 groundwater bodies are in poor quantitative status and other 31 are in good status but have a risk for poor status. The chemical status of groundwater bodies (GWB) is poor in 34 cases, and they have a risk for poor condition in 17 cases.

## Significant pressures on groundwater

A few pollutants, like nitrate, ammonia, sulphate and atrazine were identified in Hungary, which caused GWBs to fail for good chemical status, while significant increase in electrical conductivity can pose a risk in some cases. Nitrates turned out to be the dominant pollutant, but other pollutants derived either from agriculture or industries also endanger groundwater bodies. In cases of organic material or nutrient pressures, communal or industrial point sources were considered as significant. In cases of diffuse sources from agriculture, nutrients and pesticides were also considered as significant pressures. Overabstraction also endangers groundwater bodies both on local and regional scales. Abstractions without permission pose a specific pressure type mainly on shallow, but also on deeper porous groundwater bodies.

## Legal framework regarding MAR in Hungary

Although bank-filtered water supplies have a key role in Hungary in drinking water abstraction, other Managed Aquifer Recharge supplies are only sporadic in the country. Therefore there is no specific MAR legal and regulatory background and the following legislations, which are relevant, only indirectly affect this type of groundwater recharge.

As MAR type water supplies, like for example river bank-filtered water supplies are vulnerable, therefore they are subject to Government Regulation 123/1997 (VII.18.) which is on the protection of the actual and potential sources, and the engineering structures of drinking water supply. This regulation concerns their protection measures and the criteria of water protection zones.

There are other regulations relevant for the implementation of MAR schemes. For groundwater production and protection the 314/2005. (XII.25.) Government decree on the Environment impact assessment and the environmental authorization procedure and the 219/2004. (VII.21.) Government decree on the protection of groundwater regulations applies, respectively.

Separate legislation contains regulations on the authorization competences in relation to water management and water fees (72/1996 (V.22.) Gov. Decree), regulations on threshold values and pollutant measurements for the protection of the geological media and groundwater with respect to pollution (6/2009. (IV.14.) Minist. Decree), rules on groundwater monitoring (30/2004. (XII. 30.) Minist. Decree), regulations on the professional requirements of the intervention and water well drilling (101/2007. (XII.23.) Minist. decree), on general rules and regulations on activities and facilities related to the utilization, management and protection of the water resources (147/2010. (IV. 29) Gov. Decree).

An important feature of MAR policy should be a comprehensive, multi-sectoral approach. The policy recommendations and Action Plan for MAR systems have taken into account already adopted national

strategies, national action plans and programmes, as well as those set out in the 3rd River Basin Management Plan. Such strategies and programmers are:

- *National Water Strategy (Kvassay Jenő Strategic Plan)*
- *Irrigation Development Strategy*
- *National Climate Change Strategy of Hungary*
- *National Drought Strategy*
- *Flood Risk Management Plan*
- *National Landscape Strategy*
- *National Rural Development Strategy*

A better support of decision making are enabled by the DEEPWATER-CE deliverables, the transnational decision support toolbox (DEEPWATER-CE, 2021f) and the common methodology for carrying out pilot feasibility study (DEEPWATER-CE, 2020b). Figure 2. shows the procedure for the identification of potential MAR application, implementing the decision support toolbox for MAR site selection (on top) and the common methodological guidance for MAR pilot feasibility studies (bottom).

The results are the main components of common methodological guidance (DEEPWATER-CE, 2020b):

- Consideration of the regulatory framework
- Desktop study of the pilot site
- Pilot site characterization, including the determination of water demand and supply
- Risk management related to MAR implementation and operation
- Cost-Benefit Analysis (CBA) of the MAR scheme
- Comparison of alternative solutions

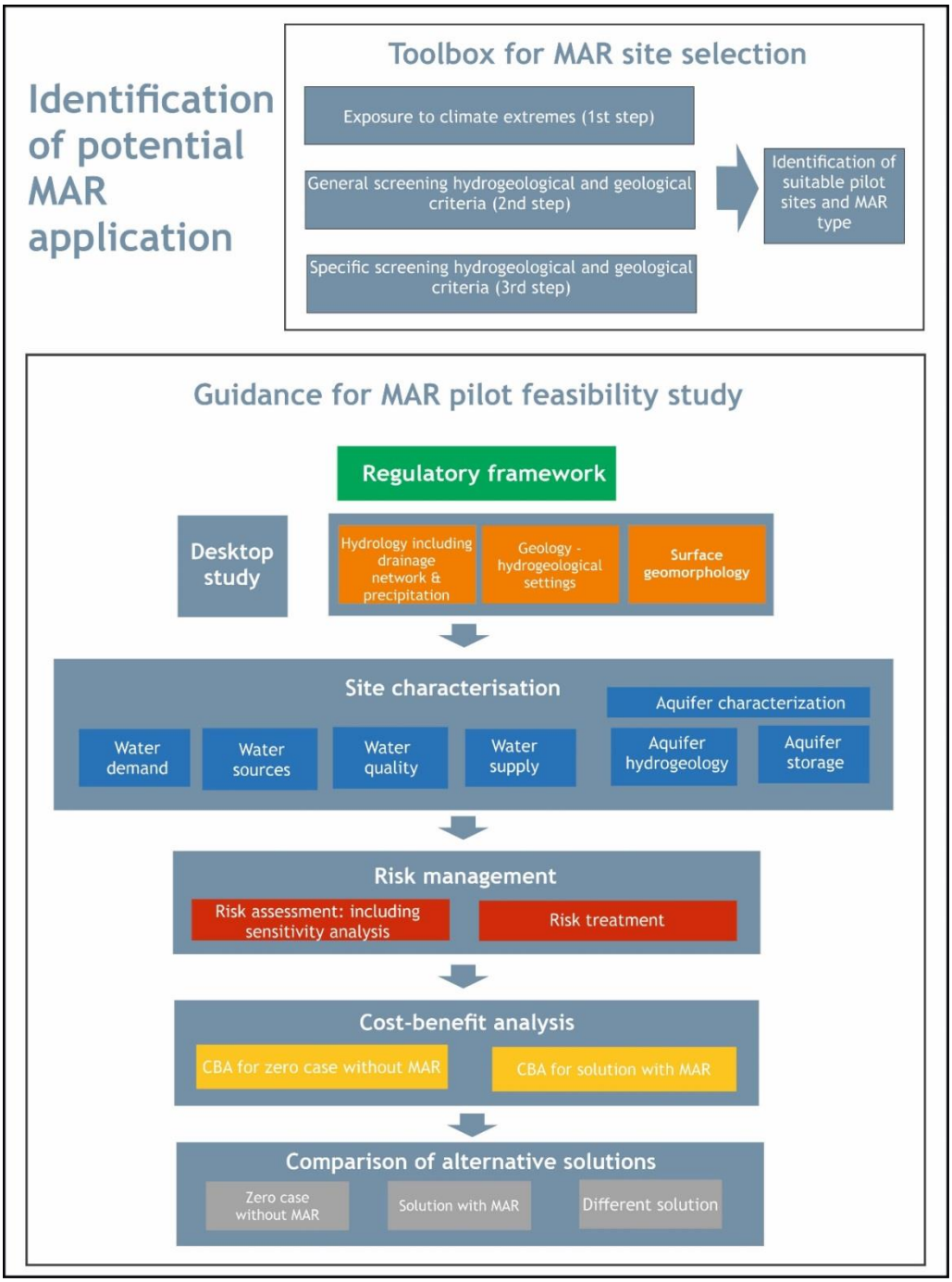


**Figure 2:** Procedure for the identification of potential MAR application, implementing the decision support toolbox for MAR site selection (on top) and the common methodological guidance for MAR pilot feasibility studies (bottom) (DEEPWATER-CE(2020b))

## 2. Vision of action plan

Climate change is expected to affect the Central European region considerably in the near future with predicted changes in precipitation amount and distribution leading to extremities in the discharge of rivers and negative effects on availability of water resources. This forecasted trend together with the increase in water demand by the different end users and sectors will potentially increase user conflicts. To handle these challenges adaptive, flexible and sustainable solutions are needed. Such potential solution can be groundwater recharge through Managed Aquifer Recharge (MAR) schemes.

The following key challenges can be addressed with the implementation of MAR schemes:

- Enhancement of the sustainable yield for the various, sometimes competing, end uses of groundwater. Overexploitation or effects of climate change can deplete the aquifer, therefore groundwater levels are significantly decreasing seasonally or on long-term.
- Retention and storage of excess surface or groundwater for future needs, due to seasonal or periodical changes and water demands (e.g. vegetation periods, ecological needs, touristic season).
- Improvement of existing groundwater quality of naturally or anthropogenically polluted areas, or maintenance of good chemical and quantitative status of groundwater bodies, as defined in WFD and RBMP.

Considering the above challenges, the DEEPWATER-CE project had several specific objectives to improve the preparedness and increase knowledge of the competent organizations for integrated environmental management of water subsurface storage through MAR. Also, in order to assess pressures and conditions for the application of MAR schemes and for the transferability to other areas comprehensive approaches of common methodology and decision support toolbox are aimed at. Finally, in order to develop a policy framework for MAR, the results of the pilot feasibility studies are translated into policy recommendations, to enhance adoption of MAR into national executive documents, national strategies and legislation.

In order to achieve the long-term objectives and the implementation of MAR the DEEPWATER-CE project summarizes a number of policy recommendations (DEEPWATER-CE, (2021d)):

- the revision of River Basin Management Plans should include an examination of the applicability of MAR as an important tool for integrated water resource management, especially in regions exposed to the effects of climate change and for water bodies at risk or in a poor condition;
- a detailed regulatory framework for MAR methods should be established;
- the need for MAR systems can be determined based on the environmental assessments of the River Basin Management Plans;
- these systems can be established on the basis of extensive, detailed examination of local conditions and pilot studies; and
- the operation of MAR systems requires the installation of monitoring systems prior to operation also for the planning phase. MAR systems can only be applied based on the operation of these monitoring systems and constant evaluation of their data. These systems should cover all parts of MAR systems and monitor their planning and operation.

The main pillars of MAR policy environment are the regulatory framework, the institutional framework including stakeholders, good practices and public awareness, which need to be established and harmonized for any MAR applications as a useful tool of integrated water resource management.

Regulation is required in order to control activities that might influence the quantity and quality of water resources which are the inherent components of the MAR scheme. This should be harmonized with

different national environmental strategies. The general governing instruments of the regulations are the EU Directives and EU Framework Directives, which are adopted in the national legislations of the CE countries and can relate to the different elements of MAR applications. The national or regional legal instruments are provided by laws and acts, government decrees and ministerial decrees for regulation and implementation. The basic tools for the implementation of the EU Directives are the main national strategies (eg. National Climate Change Strategy, National Water Strategy).

The institutional arrangements for the management of MAR applications and water resources should bring clarity to the roles and responsibilities of the national and/or regional institutions responsible for water resources. The structure of the organizations with responsibilities for both surface and groundwater has to ensure a univocal background for the implementation of regulations and water resource management. This also comprises the financial actors, operators and the authority for monitoring of a MAR project. The problem of groundwater management receiving inadequate attention under this arrangement needs to be addressed in most of the CE countries.

Well-informed, trained communities, spatial planners and water users are able to better scope out the innovative solutions providing more sustainable and attractive water management tools. Scientists have a special responsibility in raising awareness on the role that MAR can play in water management, and in guiding communities towards such novel solutions in the Central European region. Therefore, informing stakeholders and the general public is an important element of MAR policy.

## How DEEPWATER-CE contributes to the Action Plan

DEEPWATER-CE project aims at developing integrated environmental management capacities for responsible public actors of CE with a comprehensive transnational approach, to plan and manage water resources by adoption of Managed Aquifer Recharge (MAR) schemes as a potential solution to cope the negative impacts of climate change which induce declines in water supply from groundwater.

In the frame of the DEEPWATER-CE project an overview of the legislation in the project partner countries has been carried out within the frame of the DEEPWATER-CE project (DEEPWATER-CE, 2021c). Knowledge is gained through experience from around the world and provides some examples of good practices which can enhance the effectiveness of MAR applications (DEEPWATER-CE, (2019a)). Feasibility study was carried out in a pilot area (Maros alluvial fan in Hungary) as an example to illustrate a MAR scheme (in this case the underground dam) development (DEEPWATER-CE, 2021a). Gaps were identified and analysed to assure a wider application of MAR in the policy recommendations (DEEPWATER-CE, 2021e).

Based on these experiences recommended actions were collected in order to define the legal, financial, institutional and operational instruments on both local and regional levels, to facilitate safe and proper MAR operations as a potential solution to cope the negative impacts of climate change which induce declines in water supply from groundwater.

# 3. Objectives, priorities, timeline and potential funding programme of action plan, necessary institutional background

The objectives identified in the previous chapters, require the consideration of (1) technical, (2) environmental and health, (3) economic/financial, (4) social, (5) governance and (6) legislation issues. This is in line with the PESTLE (Policy, Economic, Social, Technological, Legal and Environmental issues) concept in policy development (Morrison, 2013).

For the successful implementation of MAR, the following recommendations are suggested with the proposed actions.

### Recommendation 1 Incorporation of MAR applications into national strategies

National strategies and action plans outline the strategic framework, and help establishing the planning process, identifying priorities, promoting effective management and driving implementation of MAR schemes on a longer time scale and in broader, cross-sectorial context. National strategies are not binding legally, though considered important for succeeding in legislation.

- It is needed to integrate the assessment of MAR systems into the existing relevant national strategic planning documents. These are, in particular the documents of water management and protection (National Water Strategy) and climate adaptation (National Climate Change Strategy of Hungary). There are other relevant strategic documents, such as the National Environmental Technologies Innovation Strategy, the National Drought Strategy, the Flood Risk Management Plan, the National Land Use Planning Strategy and the National Rural Development Strategy
- For the sustainable application of MAR systems a technical document shall be prepared, which will cover the entire life cycle of a MAR scheme, including the assessment of risk, control and monitoring.

It is suggested to set up a special working group of experts in hydrogeology, economics, and risk analysis to incorporate MAR into national strategies, as it is in the case of the Water Safety Plans, for example.

Actions:

1. Preparation of draft document for the implementation of MAR schemes into national strategic planning documents (National Water Strategy, National Climate Change Strategy of Hungary, National Environmental Technologies Innovation Strategy, National Drought Strategy, Flood Risk Management Plan, National Land Use Planning Strategy and the National Rural Development Strategy) regarding purpose, benefits and constraints as well as risks, control, and monitoring of MAR schemes in relation to the different strategies.
2. Setting up of a special working group of experts in hydrogeology, economics, and risk analysis in charge of the incorporation of MAR into the relevant national strategic planning documents.

### Recommendation 2 Review existing regulations to include MAR in a comprehensive way

Review regulations relevant to the entire life cycle of MAR activities, sustainability, risk assessment, control and monitoring assessment. Regulations on water accessibility through MAR system, entitlement, tradability and obligations and conditions of water use which should be specified and if necessary amended comprehensibly into current legislation. Parallel to the legislative instruments, the use of soft-rules, such as good practices, and methodological guidance documents are also recommended to support competent authorities.

The EU directives and the examples of regulations developed in some EU member states, provide the foundations of a coordinated European and national legislative environment for the implementation of MAR technologies. Some key issues are well represented in legislation which are the protection of the quality of groundwater and requirements on the water used for recharge; rules on the utilization of recovered water (it is necessary to satisfy different end-use requirements); and the prevention of adverse environmental impacts (e.g. protection of groundwater-dependent ecosystems).

- The introduction of definitions and terms related to MAR schemes specifically, as well as a more explicit incorporation of regulatory and licensing specifications for the implementation of MAR systems into national legislation should be considered.

- Direct and indirect incentives should also be developed in order to promote sustainable and innovative solutions. Water price policies should also reward the sustainable water management solutions and sanction the non-sustainable solutions. Additionally, each specific sector needs direct incentives to speed up the investments.

Actions:

3. Creation of a glossary of terms and definitions and overview of requirements for authorization/licencing relevant to MAR schemes, harmonised with the EU policy for potential future incorporation into national acts and regulations.
4. Examination of the possibility of a more explicit incorporation of MAR into legislation, especially those responsible for transposing EU legislation, such as, the Water Framework Directive, the Groundwater Directive and the Environmental Impact Assessment.
5. Preparation of a guide or a manual on the applicability of MAR and the legislative background for use by the competent authorities.
6. Development of direct and indirect incentives in order to promote sustainable and innovative solutions in the specific sectors in order to speed up investments.
7. Development of water price policies to reward the sustainable water management solutions and sanction the non-sustainable solutions.

### Recommendation 3 Suggestion of MAR incorporation into executive documents

MAR systems can be applied, as an alternative and innovative solution in order to increase the amount of groundwater that can be extracted without further deteriorating groundwater bodies with poor quantitative status. Improvement of groundwater quality status can also be enhanced by MAR systems. However, at present, MAR is not considered as a solution to improve groundwater quality. In the context of groundwater vulnerability, this could be completely ruled out in some areas but permissible in others. It could be applied especially in regions exposed the most to the negative effects of climate change and in the groundwater bodies with poor status or at risk of contamination, as an important tool for integrated water resources management. This measure is also in the interest of surface water management. MAR-specific measures are already incorporated into RBMPs in Hungary. However, to promote it further, it is recommended to include the review of the applicability of MAR methods into the River Basin Management Plan (RBMP) revisions, as a separate attachment.

- Potential areas for the implementation of MAR systems can and should be determined based on the quantitative and qualitative assessments of groundwater bodies of the River Basin Management Plans. MAR systems shall be installed based on extensive examination of the local conditions.

- For the successful implementation of MAR schemes indicators of the measures need to be elaborated, such as, groundwater levels, the quantitative status of the groundwater body, the provision

of quantitative limit values (Mi) for hydrogeological units within groundwater bodies, the amount of treated wastewater recovered, amount of water replenishment, groundwater dependent ecosystem assessment or water quality of source water and abstracted groundwater.

- The monitoring of selected indicators during the planning, operation and closure phases of the MAR system's lifespan (e.g. physico-chemical properties of source water, surface water and groundwater levels, injected yields, water treatment parameters, etc.) and regular evaluation of obtained data are needed to guarantee the fulfilment of environmental objectives of WFD, minimise risk to human health and the environment.

Actions:

8. Preparation of a review document on the applicability of MAR methods which can be included, as a separate attachment, in the River Basin Management Plan (RBMP) revisions.
9. Elaboration of methodologies and tools to survey water demands and screen potential areas for the implementation of MAR systems which could also contribute to the further characterisation of groundwater bodies in the RBMPs.
10. Development of indicator measures for the successful implementation of MAR schemes, such as, groundwater levels, the quantitative status of the groundwater body, or the provision of quantitative limit values (Mi) for hydrogeological units within groundwater bodies, the amount of wastewater recovered, amount of water replenishment, groundwater ecosystem assessment, as MAR systems can be installed based on extensive examination of the local conditions.
11. Designing the monitoring of the selected indicators during the planning, operation and closure phases of the MAR system's lifespan with respect to e.g. physico-chemical properties of source water and groundwater, surface water and groundwater levels, injected yields, water treatment parameters, etc.
12. Establishing criteria for the evaluation of obtained data to guarantee the achievement of environmental objectives and reduce risk to human health and to the environment in compliance to WFD and EIA.

### Recommendation 4 Improving information on applicability and implementation of MAR for decision making

According to the main directives of the EU and due to the high degree of legislative flexibility of the Member States – it is worth looking at the practices at national levels that were the first ones in Europe to initiate more specific regulatory processes for the consistent adaptation of MAR. Not only it is worth to have a look around the other countries legislative backgrounds, but the decision making process can be supported if there are some good practices to refer to.

In Hungary, the riverbank filtration system is widely known and applied since the 19$^{th}$ century. In addition, there is another kind of MAR application, such as, for example the infiltration pond at Borsodszirák. However, there are other MAR technologies which are unused and could be considered as potential solutions.

Flagship projects could contribute significantly to gaining experience and information on the applicability, implementation and operation of MAR systems. This way understanding of the impacts, vulnerability and risks could be strengthened through data collection, monitoring, analyses and assessment. Successful projects are also useful to demonstrate the benefits, good practices and experiences regarding MAR system.

Actions:

13. Creation of a document, which collects national and international good practices for legislation and implementation. The DEEPWATER-CE deliverables *D.T1.2.1. Collection of good practices and benchmark analysis on MAR solutions in the EU published and shared* (DEEPWATER-CE, 2019a) and *D.T4.2.1.Transational guidelines for better MAR adoption in CE region legislation and strategy (*DEEPWATER-CE, 2021d) documents can provide a good basis for this action.
14. Promotion of flagship research MAR projects.

### Recommendation 5 Education of professionals and public awareness raising on MAR applications

A useful way to promote MAR solutions in the water sector shall be by introducing the concept and its benefits to the wide public as well as to the decision makers.

Even though if we have the framework for the usage of a MAR technology, the National Strategic Plans and the benefits of MAR systems must be disseminated in the society, educational organizations, decision-making organizations, NGOs and other relevant authorities.

The engagement of the experts, as well as water and climate research-related institutes should be increased. The best way to raise awareness is by holding workshops and providing easy to access information about the applicability of MAR systems.

To inform the public about the possible usage of MAR technologies is by workshops and training which have two criteria.

- The presentations, and the provided leaflets and brochures need to be communicated in an easy to understand way.
- These workshops and trainings need to be organized locally; farmers and other interested people cannot be expected to travel, the information has to be brought to them. Workshops and trainings are recommended to be organized for both the public and the professionals.

The Ministry for Innovation and Technology already has a system in which they have workshops to help raising awareness about climate change. These workshops could be extended and build in information on MAR systems and their potential applicability.

The workshops and trainings should have different target groups, based on:

- the age: there is huge potential to educate about water awareness in schools and universities, and there is also need to have trainings for the present entrepreneurs.
- the scientific background knowledge: the presentations need to differentiate the specialists and researcher groups from the public audience, and create different documents, and present knowledge on MAR schemes from a different angle.
- the possible usage of the technology: the thematic of the presentations should fit to the audience, depending if it is a farmer group with a potential stakeholder possibility or a people who are only interested in the technology, and also those who possibly can work in a MAR installation.

Knowledge sharing innovation ecosystem bubbles should be established dedicated to MAR. In a MAR thematic bubble the public could share their problems and the experts can provide suggestions for solutions by sharing their knowledge, experience and the new research results. This way the public can be more involved in MAR researches and its application processes.

Actions:

15. Organization of workshops and trainings to different groups with different thematics.
16. Establishing of knowledge sharing ecosystem bubbles

**Table 2:** Overview of the proposed actions of the MAR Action Plan

| Formulation of the objective | Description of action | Possible contributors to action | Duration of implementation* Short-term (1 year) Medium-term (1-3 years) Long-term (>5 years) | Resources potentially available for implementation |
|---|---|---|---|---|
| **Recommendation 1 Incorporation of MAR applications into national strategies** | | | | |
| 1. Preparation of draft document for the implementation of MAR schemes into national strategic planning documents | Preparation of draft document for the implementation of MAR schemes into national strategic planning documents (National Water Strategy, National Climate Change Strategy of Hungary, National Environmental Technologies Innovation Strategy, National Drought Strategy, Flood Risk Management Plan, National Land Use Planning Strategy and the National Rural Development Strategy) regarding purpose, benefits and constraints as well as risks, control, and monitoring of MAR schemes in relation to the different strategies. | BM, ITM, AM, OVF, SZTFH | Medium-term | EU financial mechanisms, State budget, Private investments, and others |
| 2. Setting up of a special working group | Setting up of a special working group of experts in hydrogeology, economics, and risk analysis in charge of the incorporation of MAR into the relevant national strategic planning documents. | BM, ITM, AM, OVF, SZTFH | Medium-term | |
| **Recommendation 2 Review existing regulations to include MAR in a comprehensive way** | | | | |
| 3. Creation of a glossary of terms and definitions | Creation of a glossary of terms and definitions and overview of requirements for authorization/licencing relevant to MAR schemes, harmonised with the EU policy for potential future incorporation into national acts and regulations. | BM, OVF, water and environmental authorities, SZTFH | Medium-term | EU financial mechanisms, State budget, Private investments, and others |
| 4. Possible incorporation of MAR into legislation | Examination of the possibility of a more explicit incorporation of MAR into legislation, especially those responsible for transposing EU legislation, such as, the Water Framework Directive, the Groundwater Directive and the Environmental Impact Assessment. | BM, ITM, AM, OVF, water and environmental authorities, SZTFH | Medium-term | |
| 5. Preparation of a guide/manual, legislative background | Preparation of a guide or a manual on the applicability of MAR and the legislative background for use by the competent authorities. | BM, OVF, SZTFH | Medium-term | |
| 6. Development of direct and indirect incentives | Development of direct and indirect incentives in order to promote sustainable and innovative solutions in the specific sectors in order to speed up investments. | BM, ITM, AM, OVF, SZTFH | Medium-term | |
| 7. Overview of water price policies | Development of water price policies to reward the sustainable water management solutions and sanction the non-sustainable solutions. | BM, ITM, AM, OVF, SZTFH | Medium-term | |
| **Recommendation 3 Suggestion of MAR incorporation into executive documents** | | | | |

| | | | | |
|---|---|---|---|---|
| 8. Preparation of a review document on the applicability of MAR methods | Preparation of a review document on the applicability of MAR methods which can be included, as a separate attachment, in the River Basin Management Plan (RBMP) revisions. | BM, OVF, SZTFH | Medium-term | EU financial mechanisms, State budget, Private investments, and others |
| 9. Elaboration of methodologies and tools to screen potential areas for the implementation of MAR systems | Elaboration of methodologies and tools to survey water demands and screen potential areas for the implementation of MAR systems which could also contribute to the further characterisation of groundwater bodies in the RBMPs. | BM, OVF, SZTFH | Medium-term | |
| 10. Development of indicator measures for the successful implementation of MAR schemes | Development of indicator measures for the successful implementation of MAR schemes, such as, groundwater levels, the quantitative status of the groundwater body, or the provision of quantitative limit values (Mi) for hydrogeological units within groundwater bodies, the amount of wastewater recovered, amount of water replenishment, groundwater ecosystem assessment, as MAR systems can be installed based on extensive examination of the local conditions. | BM, OVF, water and environmental authorities, SZTFH | Medium-term | |
| 11. Designing the monitoring | Designing the monitoring of the selected indicators during the planning, operation and closure phases of the MAR system's lifespan with respect to e.g. physico-chemical properties of source water and groundwater, surface water and groundwater levels, injected yields, water treatment parameters, etc. | BM, OVF, water and environmental authorities, SZTFH | Medium-term | |
| 12. Establishing of evaluation criteria | Establishing criteria for the evaluation of obtained data to guarantee the achievement of environmental objectives and reduce risk to human health and to the environment in compliance to WFD and EIA. | BM, OVF, water and environmental authorities, SZTFH | Medium-term | |
| **Recommendation 4 Improving information on applicability and implementation of MAR for decision making** | | | | |
| 13. Creation of a document collecting the good practices for MAR | Creation of a document, which collects national and international good practices for legislation and implementation. The DEEPWATER-CE deliverables *D.T1.2.1. Collection of good practices and benchmark analysis on MAR solutions in the EU published and shared* (DEEPWATER-CE, 2019a) and *D.T4.2.1.Transational guidelines for better MAR adoption in CE region legislation and strategy (*DEEPWATER-CE, 2021d) documents can provide a good basis for this action. | BM, SZTFH | Short-term | EU financial mechanisms, State budget, Private investments, and others |
| 14. Promotion of flagship research MAR projects. | Promotion of flagship research MAR projects | BM, ITM, AM, OVF, research institutes | Long-term | |
| **Recommendation 5 Education of professionals and public awareness raising on MAR applications** | | | | |
| 15. Workshops and trainings | Organization of workshops and trainings to different groups with different thematics. | ITM, SZTFH, research institutes | Long-term | EU financial mechanisms, State budget, Private investments, and others |
| 16 Establishing of knowledge sharing ecosystem bubbles | Establishing of knowledge sharing ecosystem bubbles | OVF, SZTFH, research institutes | Long-term | |

*- Implementations should comply with the timeline of strategic documents.

# 4. Expected results and transferability

In order to achieve a wider applicability of MAR, the integration of objectives and measures for the use of MAR systems into the strategic planning documents, in particular into the documents of water management, river basin management plans and climate adaptation, is needed. Five key recommendations are proposed in this document, together with the necessary actions to be taken.

## 4.1. Stakeholders and their influence – policy recommendation

The Action Plan aims to be transferable to and replicable in any similar Central Europe region and context. Through the involvement of various stakeholders in workshops and roundtable discussions, the project outputs and results, as well as the Action Plan can reach academics, businesses and communities.

Stakeholder is every person, group of persons or representative of institution with an interest in MAR thematic. The identified stakeholders for MAR are the followings:

- Water suppliers, communal infrastructure and service providers
- National, regional and local authorities, decision makers, policy writers (water- and environmental authorities, responsible organizations for water and environment management)
- Researchers and experts (eg. geologists, hydrogeologists, hydrologists, meteorologists, climate change experts, engineers)
- Universities
- Representatives of the agronominal sector (eg. agronomists, foresters, farmers)
- Non-governmental organizations (NGO) (nature and water protection associations)
- General public

In the frame of the DEEPWATER-CE project a transnational database of cross-sectoral stakeholder groups (CSSG) has been set up. Stakeholders are not legally bound to participate in the DEEPWATER-CE project and its activities but rather voluntarily participate in order to create added value to the project and also benefit from its implementation and results. Cross-sectoral stakeholder groups (CSSG) contributed to recommendations on planning and preparing the national level deliverables and implementing related actions, such as training curricula, pilot actions policy recommendations, action plans, as well as participation at thematic events.

Several useful feedbacks arrived from stakeholders improving the reputation of MAR and ameliorating its life cycle. These feedbacks help not only the DEEPWATER-CE project, but also contribute to pave the way for future MAR-related projects and investments.

## 4.2 Transferability potentials

The knowledge what was created in the DEEPWATER-CE project is easily applicable, transferable and possible to use in the respective organizations and regions. Such transfer of knowledge, outputs and results address existing disparities between regions.

Regarding MAR interventions, one of the main challenges is the lack of knowledge of the potential users, as well as policy- and decision makers. The lack of knowledge leads to mistrust about MAR, and this can be a key reason why stakeholders are reluctant to invest money into such systems.

To solve the problem of missing knowledge and to raise awareness, workshops can be effective. As MAR interventions have great potential to be used to mitigate the impacts of climate change, MAR systems could be promoted for a series of thematic workshops, to reach the potential stakeholders.

In addition, it is important to start raising awareness and introducing MAR interventions through education for younger generations. This way we can help them to face the challenges of the upcoming effects of the climate change, such as drought, surface storm runoffs and intensifying water scarcity. Also, it needs to be considered that they are the potential future stakeholders.

At national level, target groups need to be identified, such as for example the farmers, and tailored information for their needs should be provided in brochures, fact sheets and guidance.

The outputs of the DEEPWATER-CE project, like the decision support toolbox and the common methodological guidelines for carrying out feasibility studies ( DEEPWATER-CE, 2021f and DEEPWATER, 2021a), help the transferability of results to different regions and for various contexts. The potentially suitable areas for the different MAR types in Hungary are shown in Figure 3.

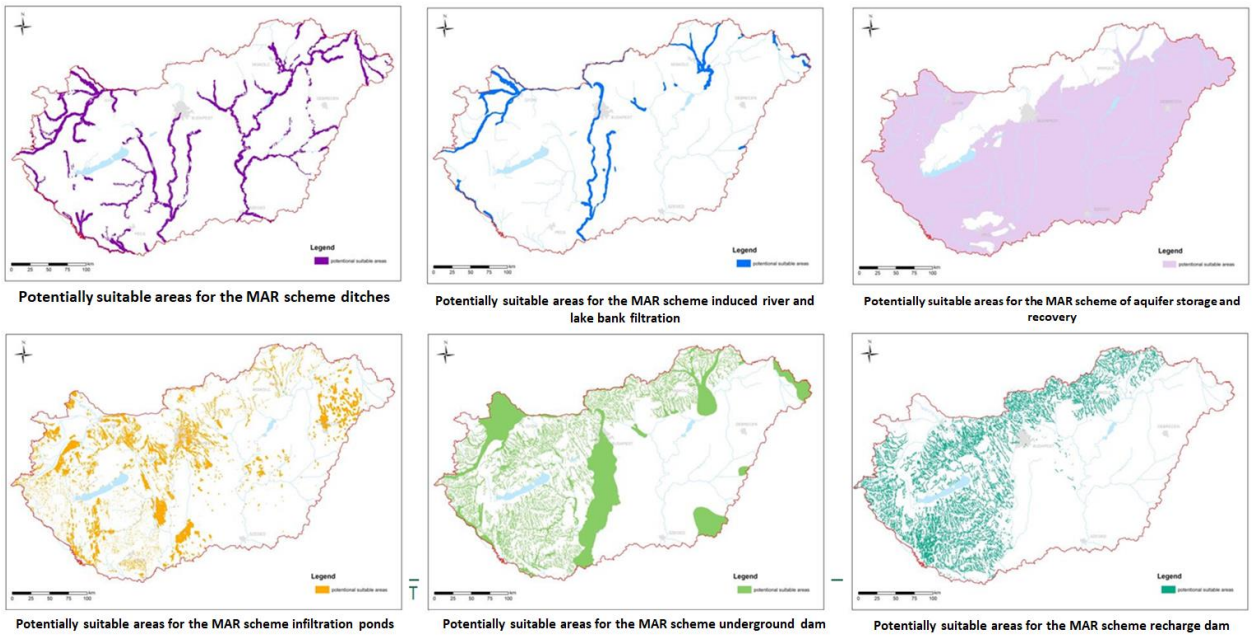


**Figure 3**: Potentially suitable areas for different MAR types resulting from country-wide screening

### 4.3 Influence on the institutional capacity of target group organisations

There are different institutes which are responsible for different aspects of groundwater management. The General Directorate of Water Management, the Ministry of Interior, Ministry for Innovation and Technology, the Ministry of Agriculture, the Supervisory authority of Regulatory Affairs Hungary, the National Directorate General for Disaster Management and its regional authorities, and the National Land Management Centre are all included in the groundwater management in some way.

These organisations are responsible for the different aspects of water management and governance, the legislations, the management of water demand, authorisation and licencing, and the implementation and monitoring of the different water technologies. To reach a better enabling policy framework for MAR, with the aim to facilitate the long-term sustainability of water supply, more integrated policy supporting efforts are needed. The best way to harmonize these different experiences is by providing platforms for these visions. Organising workshops, trainings and roundtable conversations about MAR applications can bring the different opinions together as well as it is great introduction to the implementations of MAR systems.

Not only have the authorities needed trainings about MAR, but the public as well. With the public workshops we can address the possible stakeholders and create flagship projects in the future.

For reaching further target groups the General Directorate of Water Management is planning to create innovation ecosystem bubbles where they intend to connect the knowledge and research with the potential stakeholders. This way they would provide a working system between the scientific and the implementing sides.

The Ministry for Innovation and Technology can also include MAR interventions into their workshop trainings as a potential solution for mitigating the climate change impacts on water resources. These public workshops and trainings will require more experts with time; this is why the authorities and institutes need to have regular conversations about the up-to-date MAR implementation. As a result of these institutional workshops, roundtable conversations the authorities and institutes will have more vision about the application and legal, financial background of MAR systems, which are beneficial for all participants.

## 5. Monitoring of the action plan

Monitoring is about to check the implementation possibilities of the Action Plan and assess the related results. The following table (Table 3) summarizes the suggested events, responsible organisations, discussed topics and expected results of the MAR Action Plan implementation process.

**Table 3:** Possible Action Plan monitoring occasions/events

| At which occasion / event is the Action Plan planned to be discussed? | When will be the event organised and by whom? | What will be the aim to have a discussion about the Action Plan? | What kind of conclusions / results will be expressed? |
|---|---|---|---|
| **National River Basin Management Plan Review Process Discussions** | According to the next RBMP review cycle | To include a separate MAR annex into the RBMP. | Draft document on MAR as an annex of RBMP. |
| **Working groups of competent bodies** | Harmonised with the planning phases of national strategies. | Incorporation of MAR applications into national strategies | Collection of case studies, literature, good practices taking into account different MAR applicabilities. |
| **Working group meetings** | To be defined later | Glossary of terms and guideline document preparation on MAR for authorothies | glossary of terms, guideline document on MAR |
| **National Scientific Societies, Associations and NGOs (eg. IAH Hungarian National Chapter, Hydrological Association, Geological Society, FAVA)** | Annual or ad hoc/regular thematic events | Knowledge transfer to different target groups | guideline documents, soft rules, brochure, fact sheet, online resource collection |
| **Awareness raising events** | Thematic by institutes concerned | education | brochure, fact sheet, online resources collection |

Within the framework of the DEEPWATER-CE project, it is hard to define and set up a monitoring to follow the implementation of the Action Plan. However, the bilateral and roundtable discussions carried out within the project, provided a good opportunity to learn the view of the different institutions and to inform them about the aim of the Action Plan. This ensures the relevant ministries and authorithies posess the information and are open to follow up with the actions and recommendations formulated.

# 6. Executive summary

Climate change is expected to have a significant impact on Central Europe in the near future, with predicted changes in amount of precipitation and regional distribution causing extreme events in the discharge of rivers, as well as negative effects in terms of availability of water resources. This forecast trend together with an increase in water demand from different end users and sectors could potentially increase user conflicts. Solutions to tackle these challenges must be adaptive, flexible and sustainable. One potential solution can be groundwater recharge through managed aquifer recharge (MAR) schemes, whereby excess surface water and precipitation in periods characterized by water abundance are channelled and stored in underground, in aquifers for later use.

Managed Aquifer Recharge (MAR) encompasses a suite of methods that are increasingly being used to maintain, enhance, and secure the water balance and quality of groundwater systems under stress. These methods apply techniques for increasing aquifer recharge by intentionally directing excess surface water into the subsurface. This can be done by several different methods. MAR techniques offer promising solutions for water management, also with regard to mitigating future climate change impacts (Casanova et al., 2016; Dillon et al., 2019; Dillon, 2005; Sprenger et al., 2017). This method of water management has already been applied in many places (Dillon et al., 2019;DEEPWATER-CE (2021d)).

MAR has application in sustaining and augmenting groundwater quality, quantity and also in environmental management (Grützmacher and Kumar, 2012; DEEPWATER-CE (2019a)).

The design of an appropriate MAR system can take place in several ways, depending on the geographical characteristics of the location, the type of water available for recharge, the method of recharge, the type of water treatment system and the utilisation of recovered water). Several types of potential and installed MAR systems are reported in the literature (Dillon et al., 2009b).

Although bank-filtration plays a key role in Hungarian in drinking water supply, other Managed Aquifer Recharge supplies are rare in the country, therefore there is no specific MAR legal or regulatory background.

Science based, practical evidence for MAR is contained in some DEEPWATER-CE deliverables, the transnational decision support toolbox (DEEPWATER-CE (2021f)) and the common methodology for carrying out pilot feasibility study (DEEPWATER-CE, (2020b)). Figure 2. shows the procedure for the identification of potential MAR interventions, implementing the decision support toolbox for MAR site selection (on top) and the common methodological guidance for MAR pilot feasibility studies

The objectives identified require the consideration of (1) technical, (2) environmental and health, (3) economic/financial, (4) social, (5) governance and (6) legislation issues. This is in line with the PESTLE (Policy, Economic, Social, Technological, Legal and Environmental issues) concept in policy development (Morrison, 2013).

This National Action Plan formulates suggestions for integrating MAR interventions into national water resource management schemes, strategic policy documents, water management legislation or other regulations as a comprehensive and easy-to-follow document for the decision-makers. . For the successful implementation of MAR, the following recommendations can be made, linked to proposed actions.

### Recommendation 1 Incorporation of MAR applications into national strategies

Actions:

1. Preparation of draft a document for the inclusion of MAR schemes in national strategic planning documents (National Water Strategy, National Climate Change Strategy of Hungary, National Environmental Technologies Innovation Strategy, National Drought Strategy, Flood Risk Management Plan, National Land Use Planning Strategy and the National Rural Development Strategy) regarding purpose, benefits and constraints as well as risks, control, and monitoring of MAR schemes in relation to the different strategies.
2. Setting up of a special working group of experts in hydrogeology, economics, and risk analysis in charge of the incorporation of MAR into the relevant national strategic planning documents.

### Recommendation 2 Review existing regulations to include MAR in a comprehensive way

Actions:

3. Creation of a glossary of terms and definitions and overview of requirements for authorization/licencing relevant to MAR schemes, harmonised with the EU policy for potential future incorporation into national acts and regulations.
4. Examination of the possibility of a more explicit incorporation of MAR into legislation, especially those responsible for transposing EU legislation, such as, the Water Framework Directive, the Groundwater Directive and the Environmental Impact Assessment.
5. Preparation of a guide or a manual on the applicability of MAR and the legislative background for use by the competent authorities.

6. Development of direct and indirect incentives in order to promote sustainable and innovative solutions in the specific sectors in order to speed up investment.
7. Development of water price policies to reward the sustainable water management solutions and sanction the non-sustainable solutions.

**Recommendation 3 Suggestion of MAR incorporation into executive documents**

Actions:

8. Preparation of a review document on the applicability of MAR methods which can be included, as a separate attachment, in the River Basin Management Plan (RBMP) revisions.
9. Elaboration of methodologies and tools to survey water demands and screen potential areas for the implementation of MAR systems which could also contribute to the further characterisation of groundwater bodies in the RBMPs.
10. Development of indicator measures for the successful implementation of MAR schemes, such as, groundwater levels, the quantitative status of the groundwater body, or the provision of quantitative limit values (Mi) for hydrogeological units within groundwater bodies, the amount of wastewater recovered, amount of water replenishment, groundwater ecosystem assessment, as MAR systems can only be installed after an extensive examination of the local conditions.
11. Designing the monitoring of the selected indicators during the planning, operation and closure phases of the MAR system's lifespan with respect to e.g. physico-chemical properties of source water and groundwater, surface water and groundwater levels, injected yields, water treatment parameters, etc.
12. Establishing criteria for the evaluation of obtained data to guarantee the achievement of environmental objectives and reduce risk to human health and to the environment in compliance with the WFD and EIA.

**Recommendation 4 Improving information on applicability and implementation of MAR for decision making**

Actions:

13. Creation of a roadmap, which collects national and international good practices for legislation and implementation. The DEEPWATER-CE deliverables *D.T1.2.1. Collection of good practices and benchmark analysis on MAR solutions in the EU published and shared* (DEEPWATER-CE, 2019a) and *D.T4.2.1.Transational guidelines for better MAR adoption in CE region legislation and strategy (*DEEPWATER-CE, 2021d) documents can provide a good basis for this action.
14. Promotion of flagship research MAR projects.

**Recommendation 5 Education of professionals and public awareness raising on MAR applications**

Actions:

15. Organization of workshops and training for different groups with different thematics.
16. Establishing of knowledge sharing ecosystem bubbles

In order to achieve a wider applicability of MAR in CE, the integration of objectives and measures for the use of MAR systems is needed into each country'sthe strategic planning documents, in particular into the documents of water management, river basin management plans and climate adaptation. Since the needs and potentials of regions might be different regarding the level of development and context, Action Plan needs to be transferable and of wide applicability.

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ANNEX I.

**Declaration of intent**

On behalf of the decision-making body of <name of the partner organisation> I, the undersigned, hereby declare, that the Action Plan designed in the framework of the CE1464 DEEPWATER-CE Project was endorsed and/or accepted and/or adopted by our organisation.

Date:

……..

<Name and position>

<Name of the partner organisation>

……..

*(Stamp and signature)*