

Smart framework for real-time monitoring and control of subsurface processes in managed aquifer recharge (MAR) applications

Deliverable D7.5

Two replication workshops at transfer sites

Authors

Anika Conrad (adelphi), Ronjon Heim (adelphi)



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Short summary

Replication workshops in Cyprus (October 2021) and Brazil (January 2022) have assessed site information and stakeholder views for the most promising replication sites for the SMART-Control approach. The SMART-Control approach, which includes a real-time monitoring and control system supported by a range of different web-based risk assessment and management tools, has the potential to increase water security at the sites by helping to reduce the risks associated with MAR.

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ABSTRACT

PURPOSE MAR represents a viable adaptation solution for sustainable water resources management. MAR operators and decision makers struggle to fully exploit the benefits of MAR and to integrate MAR in their water resources management supported by the public. At many existing or planned MAR sites, the lack of adequate monitoring reduces public trust, raises questions about the impact of MAR and hinders optimal operational management. SMART-Control aims at reducing these risks, by providing an innovative web-based, real-time monitoring and control system (RMCS) in combination with risk assessment and management tools.

APPROACH In order to strengthen the SMART-Control approach and help further reduce barriers for MAR and increase trust towards a safe MAR operation, the transferability of the SMART-Control solutions successfully tested at pilot sites were explored. Replication workshops were held at project locations in Cyprus (October 11th to 14th 2021) and Brazil (January 11th to 21st 2022) in the framework of replication missions covering site visits, bilateral meetings, team and public workshops. The mission followed a series of trainings and prior interaction and focused on selected sites by key stakeholders.

CONCLUSIONS In Cyprus, the focus was on further detailing out the opportunities for applying the SMART-Control approach for the existing MAR site at Akrotiri and also elaborating application options at the Germasogeia site. While some of the key stakeholders could be met and also participated at the workshops, the pandemic situation did impact the availability of some important stakeholders including the Water Development Department (WDD). In addition, the short time of the mission did not allow to visit all the potential sites mentioned, which is the scope of a follow-up replication mission. Nevertheless, some important data for the elaboration of *D7.3 Transfer concepts* could be collected.

In Brazil, site visits and bilateral meetings were conducted at both project locations in Recife and in Joao Pessoa. In both locations no full-scale MAR sites for the application of the SMART-Control approach are available, thus the focus of the mission was on planned MAR sites, envisaged by local stakeholders. The most promising site for which the transfer concept is being developed is the public market of Afogados. Here, existing infrastructure provides a good preparatory basis for a MAR system and stakeholders are ready to implement it. Further sites assessed in the Recife region is the Nannai resort and possibilities at other public markets as well as a newly setup filtration garden. In Joao Pessoa, two public locations, the convention centre and the cultural centre, were assessed, which seemed suitable technically but actually did not have a requirement for increasing the water resource usage efficiency as sufficient water is available currently. This could change in future due to extensive development plans in the area of the conference centre. Further areas with more requirement for efficient water resource management were identified to be further inland in the areas of Areia and Bananeiras.

Both replication missions showed that there is a scope for follow-up research projects on the feasibility of the SMART-Control approach. Details for two of the most promising sites are elaborated in *D7.3 Transfer concepts*.

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ABBREVIATIONS

ASR	Aquifer Storage and Recovery
APAC	Water and Climate Agency of Pernambuco
COMPESA	Water utility of Pernambuco
CSURB	Urban Services Company of Recife
ECoE	Erastosthenes Centre of Excellence
GSD	Geological Survey Department of Cyprus
NA	not available
MAR	Managed Aquifer Recharge
PI	Performance Indicators
RMCS	Real-time Monitoring and Control System
TUD	Technical University of Dresden
UFPB	Federal University of Paraiba
UFPE	Federal University of Pernambuco
WDD	Water Development Department, Cyprus

1 INTRODUCTION

1.1 BACKGROUND

MAR, referring to the intentional recharge of water to aquifers (Dillon 2015), represents a viable adaptation solution for sustainable water resources management and is successfully applied worldwide for the restoration of affected groundwater-dependent ecosystem services (Stefan and Ansems 2018), including: freshwater production and availability, flood mitigation, prevention of saltwater intrusion, restoration of depleted aquifers, seasonal water storage, improvement of water quality, land renaturation, as well as increasing the aesthetic values of water bodies. Despite its financial and ecological benefits, the contribution of MAR to safe water supply at global scale is still limited. The reasons include the lack of data on the technological costs of MAR, the hydrogeological site characteristics, the associated risks and, at many sites, the lack of adequate monitoring, which reduces public trust, raises questions about the impact of MAR and hinders optimal operational management.

1.2 ABOUT THE SMART-CONTROL PROJECT

SMART-Control aims at reducing these risks in the application of sustainable groundwater management techniques, by the development of an innovative web-based, real-time monitoring and control system (RMCS) in combination with risk assessment and management tools. At pilot sites in-situ-real-time monitoring systems consisting of state-of-the-art online sensors are installed and new web-based tools for control, modelling and prediction are developed (available under <https://inowas.com/>). Following key risks in water reuse applications will be considered against quantifiable performance indicators (PI):

- public health (PI: microbial concentration in water reuse below 10⁻⁶ µDALYs per person per year)
- environmental risks (PI: spatial and temporal extent of infiltration bubble by water quality parameters e.g. nitrogen concentration, salinity)
- clogging management (PI: maintenance intervals)
- recovery efficiency (PI: recovery of water with defined quality in %)
- residence time (PI: subsurface residence time in days from estimation-based approach with unknown uncertainties to real-time assessment with quantifiable uncertainties).

The approach is tested at a total of six pilot sites in Brazil, Cyprus, France and Germany under different environmental and operating conditions to reach a wide range of objectives: increase water availability in urban areas, prevent saltwater intrusion in coastal aquifers and mitigate extreme climatic events. Reducing the risks associated with MAR facilities increase their manageability and controllability. This leads in a broader sense to the promotion of social acceptance of water reuse technologies and demonstrates the feasibility of MAR as climate change adaptation measures. A more detailed description of the SMART-Control approach can be found on the project website: <https://smart-control.inowas.com/>.

1.3 REPLICATION ACTIVITIES

In order to strengthen the SMART-Control approach and help further reduce barriers for MAR and increase trust towards a safe MAR operation at sites outside the project pilot areas, the transferability of the SMART-Control solutions successfully tested at pilot sites are explored. Replication activities are conducted to assess needs associated with MAR risks and co-develop replication ideas for the SMART-Control approach with the project site partners and stakeholders of MAR sites.

Transfer sites were sought in the vicinity of the project pilot plants in order to be able to use the knowledge gained there and, above all, to be able to present these to potential stakeholders as examples of best practice. Of the six pilot plants in the SMART-Control project, replication activities were carried out at the sites that are still less advanced in terms of MAR development and corresponding stakeholder networks: Brazil and Cyprus. Depending on the state of development of MAR at the potential transfer site, different SMART-Control solutions are interesting to reduce the risks associated with MAR, including risks during planning, implementation or operation

of MAR. The team considers the following site categories, which are differentiated according to MAR system and monitoring system status:

- 1 - no existing MAR sites yet, but MAR is planned
- 2 - MAR sites without monitoring system
- 3 - MAR site with existing analogue monitoring system
- 4 - MAR location with existing online monitoring system

Besides potential and active MAR operators, MAR stakeholders (of existing or planned MAR sites) are also engaged in the activities and discussions are taking place in order to consider all potential benefits for a replication project (e.g. farmers as end-users of the recovered water, water utilities as water suppliers, water agencies as decision and policy makers). The range of replication activities includes field visits, bilateral meetings with key stakeholders and public events aiming the below listed specific objectives:

Bilateral meetings and site visits

- to assess the latest developments at the Ezousas project pilot site and the site conditions and applicability of the SMART-Control solutions to transfer sites and identify optimisation opportunities for an existing or planned MAR site

Replication workshop

- To present project results including newly developed SMART-Control tools, models, etc. that address local needs
- Joint development of specific solution options for the application of the SMART-Control approach for the optimisation of existing or planned MAR systems in Brazil and Cyprus, which will be developed using a three-step approach:
 - i. Identifying and assessing local risks and needs (based on prior consultations and results of the replication meeting that have been conducted at the end of the training week)
 - ii. Matching SMART-Control tools with the identified local needs for solution development and identify site-specific solution concept
 - iii. Compiling application examples for tools to demonstrate best practices (from Ezousas pilot or from the other project pilots)

Public event

- To raise awareness on the opportunity to mitigate risks associated to MAR and improved monitoring and control systems (SMART-Control approach) among a wide range of stakeholders from different fields
- Validate and finetune identified transfer concepts
- Outlining a follow-up project with tasks, partners and potential funding opportunities

Due to Corona-related restrictions on physical workshops, a public event was not held during the replication mission in Brazil. Instead, the focus was on individual bilateral meetings.

This report provides the detailed agenda of the replication activities carried out in Cyprus from 11-14 October 2021 (section 2) and Brazil 10-21 January 2022 (section 3) and their key outcomes. Follow-up replication activities are planned in Cyprus in May 2022, the key findings of which will be subsequently added to this deliverable.

2 REPLICATION MISSION TO CYPRUS

Timing: 11 – 14 October 2021

Attendees from the project team: Anika Conrad (adelphi), Ronjon Heim (adelphi), Catalin Stefan (TUD), Konstantinos Panagiotou (here: Kostas, Erastosthenes Centre of Excellence)

2.1 AGENDA

Table 1. Agenda of the replication mission to Cyprus

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
11 October 2021 – Bilateral meetings with core stakeholders					
08:00 – 08:15	Internal meeting in Limassol, preparing day				Catalin, Robert, Kostas, Ronjon, Anika
Car ride from Limassol to Ezousas (approx. 60 min)					
9:00 - 10:00 (60 min)	Andreas Chrysanthou (Farmer Union in Paphos, NGO) Location: Ezousas environmental centre	Identifying future project opportunities to exploit the SMART-Control solutions	Presenting recent project results and replication approach Discussing future collaboration opportunities	Detailed plan of the replication activities, list of confirmed participants	Kostas, Catalin, Robert, Ronjon, Anika
10:00 - 11:00 (60 min)	Diofantos G. HADJIMITSIS (Coordinator of the Erastosthenes Centre of Excellence) Location: Ezousas environmental centre	Identifying future project opportunities to exploit the SMART-Control solutions	Presenting recent project results and replication approach Discussing future collaboration opportunities	Detailed plan of the replication activities, list of confirmed participants	Kostas, Catalin, Robert, Ronjon, Anika
Travel from Ezousas to Nikosia (approx. 1 h 40 min)					
13:00 – 13:45 (45 min)	Geological Survey Department	Coordination and preparation of last important points for the week with the core stakeholders	Receive an update on the stake on Akrotiri and Germasogeia Clarify on roles and participation in the week Discuss the scope of the Tuesday Workshop and the Thursday Public event	Detailed plan of the replication activities, list of confirmed participants	Kostas, Ronjon, Anika
15:00 – 16:30 (90 min)	University of Cyprus /NIREAS/Agricultural Institute? Food(lunch) with Panos Location: Kyrenias 96, Aglantzia, Zypern				Send out last invitations for public workshop, clarify exact desired contribution of core stakeholders to the activities.
12 October 2021 – Replication workshop with core stakeholders from both identified new sites: Akrotiri site (Type 3 – MAR site with existing analogue monitoring system) and Germasogeia site (Type 1 – no existing MAR site yet, but MAR planned)					

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
09:00 – 09:15 (15 min)	Welcome and short introduction	The participants know what to expect from the day	Objectives, agenda, participants share their expectations on sticky notes	Ppt, Sticky notes	Ronjon/Anika
09:15 – 10:00 (45 min)	Recap of the SMART-Control project	The participants receive an overview of the project objectives, review of 3 years of project activities, recent project results, benefits which can be replicated and outlook	Overview of a MAR scheme with components which can be addressed with the tools (Catalin) Link to diagram with all MAR components and tools and remote sensing (general context, wider perspective) CBA, Results and GW-Model of the Ezousa site (Kostas)	ppts	Catalin, 20min Kostas 20 min presentation + 5 minutes Q&A)
10:00 – 10:15 (15 min)	Needs identified for the Akrotiri site	Recap and verify the results of the replication session from the training last year	Clarify on the MAR system Present the results of the Miro Board Go through the risks, measures to reduce these risks and conclude on the three options which are presented in detail in the following sessions	Projector with internet or ppt	Anika
10:15 – 10:35 (20 min)	Benefit of MAR setup: optimal design with at Germasogeia	The participants are aware of the SMART-Control's potential to meet their communicated needs and understand how to apply selected tools.	Need 1: Location of recharge ponds to increase availability → Numerical GW modelling and optimization (tool 3) Presenting of results from tool 3 to create GW model at Ezousasa and potential MAR setup at GERmasogea, to understand the model, required sensors, group discussion	Ppt, INOWAS platform	Kostas
10:35 - 10:55 (20 min)	Saltwater Intrusion mitigation: Impact of MAR on intrusion and sustainable abstraction		Need 2: Optimisation of the recharge system to alleviate seawater intrusion Present T3c to assess saltwater intrusion in coastal aquifers and the impact of the MAR scheme to mitigate saltwater intrusion Present T9 seawater intrusion tool d) critical well discharge to identify the abstraction rates possible without risking saltwater intrusion	Ppt, INOWAS platform	Catalin, Robert

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
10:55 – 11:10 (15 min)	<i>Coffee break</i>				
11:10 – 11:30 (20 min)	Needs identified for the Germasogeia site	Recap and verify the results of the replication session from the training last year	Clarify on the MAR system Present the results of the Miro Board Go through the risks, measures to reduce these risks and conclude on the three options which are presented in detail in the following sessions And possibly identify further needs/risks, which can be addressed and which will be noted for later discussions	Projector with internet or ppt and sticky notes	Ronjon
11:30 – 11:50 (20 min)	Health Benefits: Improving the water quality at Germasogeia or Akrotiri MAR site	The participants are aware of the SMART-Control's potential to meet their communicated needs and understand how to apply selected tools	Need 1: Monitor pathogens → Assess Soil Treatment and QMRA T19 general application scope for GW residence time and additional treatment requirement. Conclusions for T15 T15 Present QMRA tool, application example at Ezousas site, required sensors, group discussion	Tool, model, required sensors	Kostas 15 min/ Ronjon 5min
11:50 – 12:10 (20 min)	MAR Scenarios: Benefits of adapting MAR to the future in Akrotiri	Same as above	Need 2: Monitor water quantity in future → future scenario analysis tool 7 Present Scenario tool, GW model and application example at Ezousa site, (this might be prepared in advance/discuss with Kostas), required sensors, group discussion	Tool, model, required sensors	Anika
12:10 – 12:30 (20 min)	Wrap up and feedback on the presented solution concepts for both sites Further Needs and Options	Verify the selection of needs and tools Discuss possible application of tools for newly identified needs Work out requirements for the adaptation/extension or even development of new tools for the INOWAS platform	Guiding questions: Do the tools address the core needs at the sites adequately? Is there any need to adapt/extent/verify the presented tools or to newly develop tools in order to efficiently address the risks? What is the scope to mitigate newly identified risks with a SMART-Control tool? Which tool would be most suitable?	Open Discussion with Flipchart, Inowas Platform and website	Catalin Robert, Kostas, Anika, Ronjon

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
12:30- 13:00 (30 min)	Planning programme for the public event	Clarify roles, responsibilities of the organising stakeholders on the public event, ensure participation of relevant participating stakeholders, clarify on last minute organisational issues	Guiding questions: Which SMART options will we present at the public event? Who will present these options? What needs to be prepared in this regard? Which additional stakeholders are to be specifically invited? Who will approach and invite these stakeholders? Are all organisational preparations taken care of?	PPT with draft agenda and suggested speakers	Ronjon , Kostas, WDD (tbd)
13:00 – 14:00 (60 min)	<i>Lunch break</i>				
14:00 – 17:00 (3 h)	Joint excursion to the Akrotiri and Germasogia basin for site assessment: potential MAR setup, location of sensors, etc.	The participants know how to optimize the (potential) technical MAR setup	Due to the proximity of the two potential replication sites, both will be visited in succession, discussing questions such as: where should which sensors be installed, where should recharge ponds be best placed (in the case of Germasogeia site), etc.	Site visit with rented car	all
13 October 2021 – Bilateral Meetings for preparation of the public event and the development workshop					
10:00 -17:00	Internal Meeting	Preparation of development workshop, clarification on roles	Last minute preparations for the next day	Informal discussion	Catalin, Kostas, Anika, Ronjon
14 October 2021 – Public event with stakeholders/end user and development of implementation opportunities for future projects					
9:00 – 9:10	Keynote on Smart MAR for Akrotiri and Germasogeia	Set the stage and frame of the public event, local stakeholders are aware of the efforts conducted for water security	Introduction to the project and activities so far Water security challenges in Akrotiri and Germasogeia	PPT with project introduction and wrap up of the activities so far, Risks identified at the sites	WDD(Filio Ioulianou) / GSD?
9:10 – 9:30	Suggested solutions: Risk Mitigation opportunities at the two replication sites	Local stakeholders are informed on the measures suggested for the two sites which lead to more benefits and	Presentation: Present ideas on improvement options related to the SMART approach evolved in the prior two workshop days to end users for	Ppt with improvement suggestions, SMART-Control platform for	Farmer Union (Andreas), UC/Nireas(Kostas) If no stakeholder

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
		increased acceptance towards MAR	increasing their acceptance towards MAR	presenting examples,	s want to present: Catalin, Kostas,
9:30-9:45	Views on the effectiveness of the suggested measures for co-creating project ideas	Participants can share their views on the suggested measures	Interactive discussion: Seek the opinion of end-users on the effectiveness of the risk mitigation with the suggested SMART approach	Open discussion	Ronjon, Anika
9:45-10:00	Brainstorming on potential further risks which have not been addressed and opportunities for addressing them with a SMART approach	MAR operator and project team receive feedback by end users incl risks that might have been overseen to further improve reputation of the MAR site	Interactive discussion: Brainstorm on further risks that may need to be addressed	White board for collecting feedback from the stakeholders	Anika, Ronjon,
10:00 – 10:15	Closure and Outlook	Conclusions for the replication opportunities are summarised Outlook for potential project development is communicated Interested stakeholders commit their participation in the project development	Most feasible application opportunities of the tools for both sites are summarised taking into consideration the feedback of the participants Intention of developing follow up projects for the two sites Stakeholders who are interested in the project development speak out and mention their potential roles	Speech, Whiteboard noting interested stakeholders	WDD, Catalin, Anika
10:15 – 11:00	<i>Coffe break/ change of rooms/ leave of general stakeholders</i>				
11:00 – 12:30 (1 h 30 min)	Development of project concepts and roadmap for Akrotiri and Germasogeia sites	Outline a follow up project with Tasks, Partners and potential funding opportunities	Main objectives of the new project Main beneficiaries and stakeholders Tasks to be looked into and resources required Resources available and roles of partners Potential additional resources to be organized Programmes and funds which are available Next Steps and ToDos	Prepared constellations for project implementation in the form of a miro board or sticky notes	Anika, Ronjon, Catalin, Kostas
Latest 13:00	German partners need to depart for the airport				

2.2 KEY OUTCOMES OF THE ACTIVITIES IN CYPRUS

2.2.1 Meeting with the Farmer Union in Paphos

Date / Time	Programme	Objective	Detailed agenda	Materials and methods	Resource person
11 October 2021					
9:00 - 10:00	Andreas Chrysanthou (Manager of the Farmer Union in Paphos, NGO) Location: Ezousas environmental centre	Identifying future project opportunities to exploit the SMART-Control solutions Representative of the farmer unions agrees to participate in and contribute to the replication workshop and public event Invitation to upcoming replication activities is forwarded to other key stakeholders	Presenting recent project results and replication approach Discussing future collaboration opportunities Prepare participation and contribution of the Farmer Union in the upcoming replication workshop and public event Send out last invitations for public workshop, clarify exact desired contribution of core stakeholders to the activities.	Detailed plan of the replication activities, list of confirmed participants	Kostas, Catalin, Robert, Ronjon, Anika

Key outcomes

The Farmer Union of Paphos is generally interested in a future collaboration within the framework of a research project. Interesting topics for the Farmer Union are the optimisation of the Ezousas MAR plant and the resulting improvement of the quality of the recovered water used by the farmers for irrigation purposes. Recently, farmers have been complaining about the bad smell of the recovered water. There is a general fear of contamination with pathogens/mistrust of the water quality, and its impact on the animal productivity (e.g. milk). The SMART-Control approach could help to optimise the retention time of the infiltrated water in the subsurface/ vadose zone, which is an indicator of the cleaning performance of the MAR system. Real-time monitoring with an integrated warning system and appropriate, user-friendly visualisation could help increase trust of the farmers.

The district secretary of EKA Farmer Union of Paphos, Andreas Chrysanthou, also heads the environmental centre and is responsible for an extensive ecological conservation programme in the Ezousas river basin. Questions about the contribution of MAR to nature conservation are also important to him. However, compared to the national park, the infiltration ponds of the MAR sites are located further downstream near the coast. Transporting the water upstream would be too costly. Surrounding agricultural fields are supplied by another water source. Nearby villages are not connected to a WWTP and have their own septic tanks, which makes implementing MAR challenging at first. However, optimising the exiting MAR system downstream could substitute the usage of water



Figure 1. Meeting with the EKA Farmer Union of Paphos at the Environmental Center

from the Ezousas catchment and its availability for ecological purposes. The need for more and clean water is stressing, not only to supply the surrounding farmers, but also to preserve the often-overlooked biodiversity and ecosystems services of the Ezousas Basin. This topic could be a focus of future cooperation.

Additionally, Andreas Chrysanthou is interested in participating in a public event on the application of MAR and the SMART-Control concept to increase water security in the region by optimising its MAR approach and in representing the Farmer's Union of Paphos with contributions. He will forward the invitation to other key stakeholders.

2.2.1 Meeting with the Eratosthenes Centre of Excellence

Date / Time	Programme	Objective	Detailed agenda	Resource person
11 October 2021				
10:00 - 11:00	Diofantos G. HADJIMITSIS (Coordinator of the Eratosthenes Centre of Excellence) Location: Ezousas environmental centre	Identifying future project opportunities to exploit the SMART-Control solutions Invitation to upcoming replication activities is forwarded to other key stakeholders	Presenting recent project results and replication approach Discussing future collaboration opportunities	Kostas, Catalin, Robert, Ronjon, Anika

Key outcomes

The Eratosthenes Centre of Excellence (ECoE) is generally interested in a future collaboration within the framework of a research project. The ECoE is specialised in remote sensing of land use and cover, flood monitoring etc. The centre collects versatile satellite data such as chlorophyll, Particulate Organic Carbon (POC), turbidity, etc. for this purpose. In relation to MAR, existing data could be used to determine the water quality of the infiltration ponds and hence clogging potential as well as salinity. Currently groundwater is still a white spot for the centre, it would be interesting to combine surface data with groundwater sensor data and hydrogeological modelling. This could provide information on the impact of MAR on biodiversity and nature conservation. For that purpose, the Centre has recently submitted a proposal. The inclusion of economic benefits is also of great importance. Professor Hadjimitsis informed the project team about two upcoming calls managed by ESA spending a budget of 1.5 million for applied research. The call topics are not specific to water, but include remote sensing and navigation and could therefore be interesting for the questions described above. The participants of the meeting agree to stay in contact and to look for suitable upcoming calls.

2.2.2 Meeting with Geological Survey Department

Date / Time	Programme	Objective	Detailed agenda	Resource person
11 October 2021				
13:00 – 13:45 (45 min)	Dr. Christos Christophi and Michael Rigas and Thesodosia, Geological Survey Department (GSD)	Identifying future project opportunities to exploit the SMART-Control solutions Representative of GSD agrees to participate in and contribute to the replication workshop and public event Invitation to upcoming replication activities is forwarded to other key stakeholders	Presenting recent project results and replication approach Discussing future collaboration opportunities Prepare participation and contribution of GSD in the upcoming replication workshop and public event Send out last invitations for public workshop, clarify exact	Kostas, Catalin, Robert, Ronjon, Anika

Date / Time	Programme	Objective	Detailed agenda	Resource person
			desired contribution of core stakeholders to the activities.	

Key outcomes

The GSD has a very good overview of the groundwater availability and also about sites, which are generally technically suitable to be explored on further for groundwater recharge. The selected site for identifying replication options (Akrotiri) seem to be very relevant and would have synergies with ongoing studies GSD is conducting. Germasogeia also would be a very relevant site. GSD would generally be interested to cooperate on improving MAR systems in Cyprus and sees opportunities



Figure 2. Meeting with GSD

for upscaling existing systems as well as exploring more sites for their suitability, as more pressure on the existing water resources is being foreseen in future making efficient water resource management including water reuse necessary at all levels and all potential locations. Limitations of involving local stakeholders were seen at this point of time due to the Corona restrictions. It was discussed to look into conducting meetings with representatives from the WDD at a more suitable time, as they need to be involved in any water resource planning activities in Cyprus. For future projects GSD could be a partner and would appreciate to be involved at an early stage in order to shape the objectives of a project. GSD also suggested to go through the existing works and studies on the Cyprus aquifers, which should be referred to when planning MAR systems. GSD would participate in the public workshop but prefer to participate online, rather than travel to Limassol, due to Corona-related and time reasons.

2.2.3 Replication workshop with key stakeholders from identified replication sites (Akrotiri site and Germasogeia site)

Date / Time	Programme	Objective	Detailed agenda	Resource person
12 October 2021				
09:00 – 13:00	Replication workshop with key stakeholders of the Akrotiri site and Germasogeia site	<ul style="list-style-type: none"> Key stakeholders are aware of the SMART-Control's potential to meet local needs and understand how to apply the SMART-Control approach including relevant tools. specific solution options for the application of the SMART-Control approach at transfer sites are developed feedback on the adaptation/extension or even development of new tools for the SMART-Control platform are received Roles, responsibilities for the public event are clarified and participation of relevant stakeholders are ensured 	<p>Recap of the SMART-Control project, verify identified needs identified for both replication sites, Presentation of selected SMART-Control tools suitable to address identified needs and discussion in their application</p> <p>Wrap up and feedback on the presented solution concepts for both sites, Planning programme for the public event</p>	Kostas, Catalin, Robert, Ronjon, Anika

Date / Time	Programme	Objective	Detailed agenda	Resource person
		<ul style="list-style-type: none"> last minute organisational issues are clarified 		
13:00 – 14:00 (60 min)	<i>Lunch break</i>			
14:00 – 17:00 (3 h)	Joint excursion to the Akrotiri and Germasogia basin for site assessment: potential MAR setup, location of sensors, etc.	The participants know how to optimize the (potential) technical MAR setup	Due to the proximity of the two potential replication sites, both will be visited in succession, discussing questions such as: where should which sensors be installed, where should recharge ponds be best placed (in the case of Germasogeia site), etc.	all

Attendees of the replication workshop in Cyprus: George Leventis (ECoE, CUT), Filio Ioulianos (WDD), Christos Christofi (GDS), Eleni Lolelli (ECoE, CUT), Popi Karaolia (NIREAS), Panos Papanastasiou (UCY), Charalampos Konstantinou (UCY), Konstantinos Panagiotou (ECoE, UCY), Catalin Stefan (TUD), Robert Schlick (TUD), Ronjon Heim (adelphi), Anika Conrad (adelphi).

Key outcomes

Based on the initial results of the replication meeting held during the training week in Cyprus, the project team developed specific solution concepts for the application of the SMART-Control approach at two selected transfer sites (Akrotiri site and Germasogeia site), which have been discussed and substantiated at the replication workshop with key stakeholders.

These include an analysis of site conditions and identification of local water security needs, assessment of existing solutions as well as future scenarios regarding water management, treatment and supply, assessment of the current status of MAR installation, associated risks and potential for improvement as well as expected benefits using the SMART-Control approach. In case of the Germasogeia site where no MAR system is yet in place, an entry-level feasibility assessment was conducted. In addition, the stakeholder landscape was analysed to identify beneficiaries and partners of a potential replication project. An overview of the information collected during the workshop including water-related risks, needs and stakeholder landscape at the Akrotiri and Germasogeia site are provided in Figure 4 and Figure 5. Based on these findings, specific solution concepts were developed, including relevant SMART-Control tools that address the identified local needs. Figure 6 shows the selected SMART-Control tools and associated components of the MAR systems at the Akrotiri site that can be optimised with the selected tools. As the water-related needs at the Germasogia site are similar to the Akrotiri site, the same set of SMART-Control tools can be used to help optimise the planning of a MAR system. However, which MAR type is most suitable for Germasogia can only be decided on the basis of additional hydro-geological studies.

The developed solution concepts have been discussed and refined in the course of the replication mission in the subsequent public event with a broader group of stakeholders. The detailed elaboration of the solution concept for the Akrotiri site can be found in *D7.3 Transfer concepts*.

In addition to the two sites mainly discussed during the workshop, it was also brought up that there are further sites in Cyprus, which could be explored for their suitability for MAR in the light of having the assessment and modelling tools at hand. Initial studies showed that various aquifers in Cyprus are facing problems related to overexploitation and thus could potentially have capacities for being recharged. Among these sites are Kokkinochoria, Kiti, Peyeia, Polis Chrysochou and also the various aquifers connected to Cyprus biggest catchment Troodos. It was decided that these would not be the scope of this replication mission but could possibly be looked into in a follow-up mission.

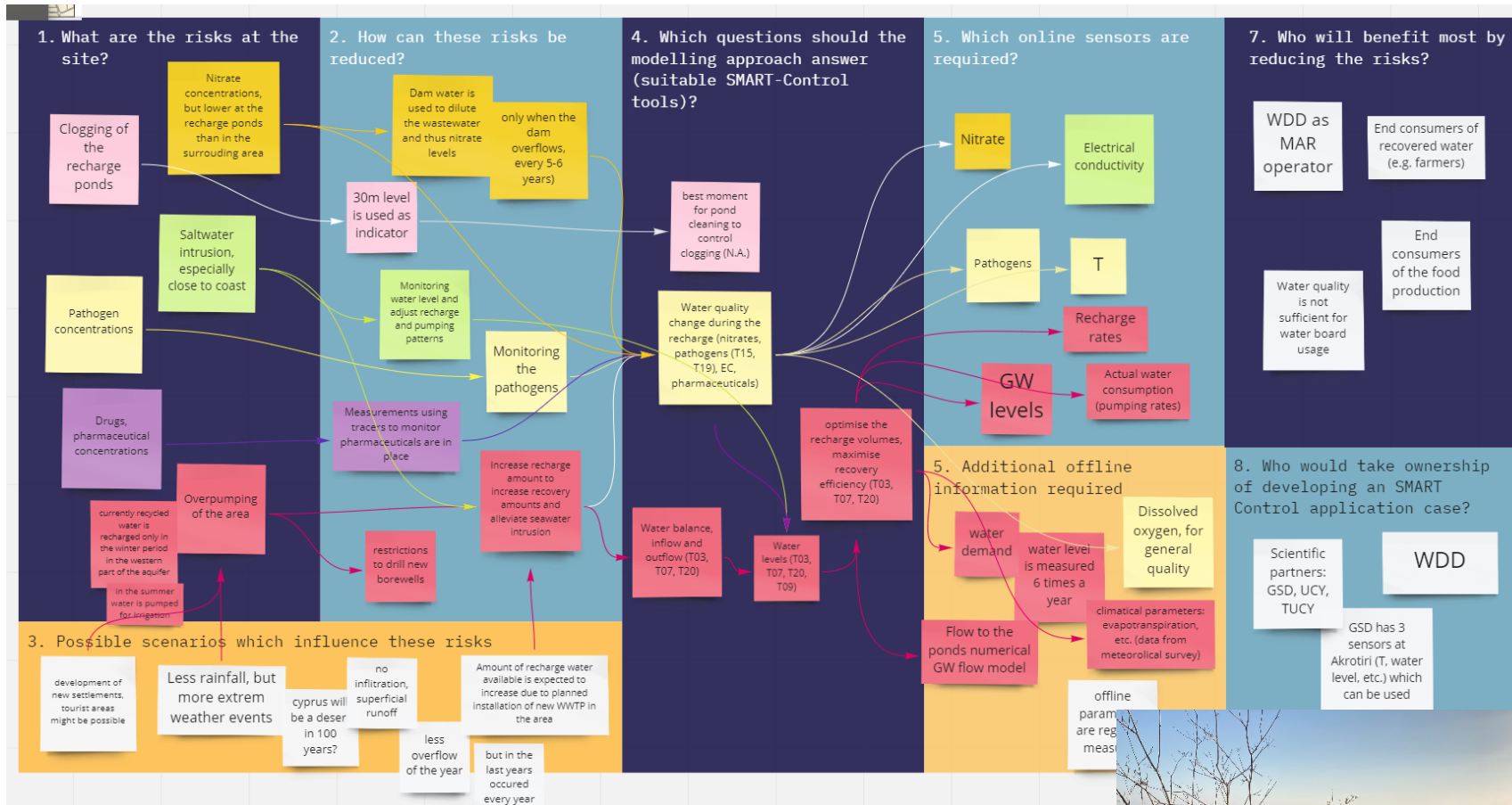


Figure 3. Identified risks, needs and stakeholder landscape at the Akrotiri site



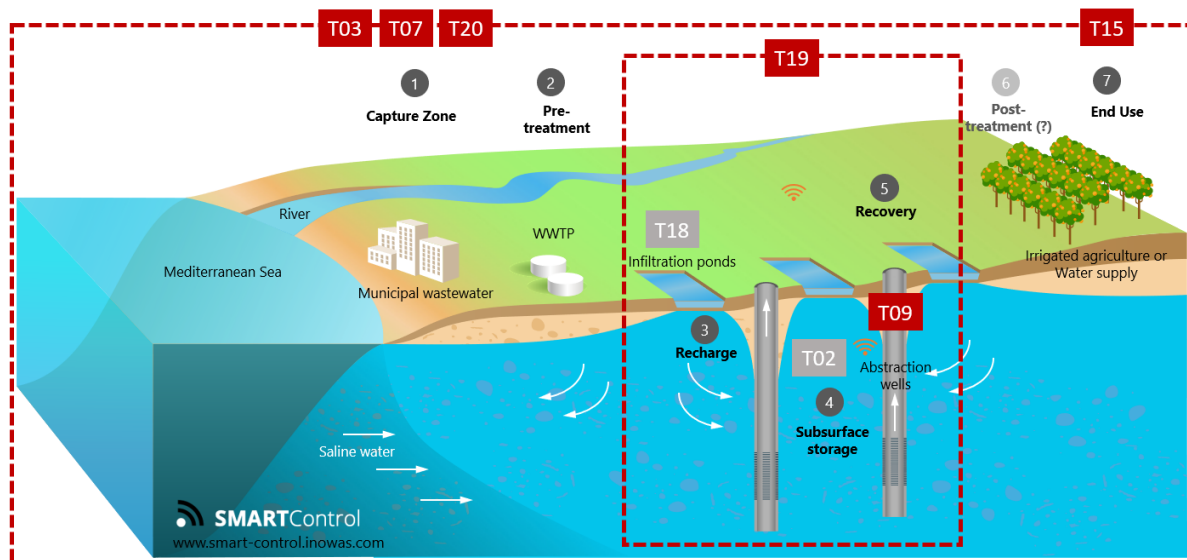


Figure 5. SMART-Control tools relevant to address stakeholder needs at the Akrotiri site in Cyprus

Tool	Description	Tool	Description
T02	Groundwater mounding calculator	T15	Qualitative microbial risk assessment (QMRA)
T03	Numerical groundwater modelling and optimisation	T18	SAT basin planner
T07	MODFLOW model scenario manager	T19	Groundwater hydraulic residence time calculator
T09	Analytical saltwater intrusion equations	T20	Real-time numerical groundwater modelling

2.2.4 Public event with various stakeholders and development workshop for specific future projects

Date / Time	Programme	Objective	Detailed agenda	Resource person
14 October 2021				
9:00 – 10:30	Public event	Local stakeholders are aware of the benefit of the existing/planned MAR system to safeguard the local water resources and are informed on the optimisation opportunities. Participants shared their views on the suggested measures with the MAR operator and SMART-Control project team. Conclusions for the replication opportunities are summarised. Outlook for potential project development is communicated. Interested stakeholders commit their participation in the project development.	<ol style="list-style-type: none"> 1. Introduction to the SMART-Control project and replication activities 2. Water security challenges in Akrotiri and Germasogeia 3. Risk Mitigation opportunities at the two replication sites 4. Participants' views on the effectiveness of the suggested measures 5. Brainstorming on potential further risks not mentioned yet and opportunities for addressing them with the SMART approach 6. Closure and Outlook 	Filio Ioulianou (WDD), Christos Christophi (GSD), Andreas Chrysanthou (Farmer Union in Paphos, NGO), Kostas, Catalin, Robert, Ronjon, Anika

Date / Time	Programme	Objective	Detailed agenda	Resource person
10:30 – 11:00	<i>Coffe break/ change of rooms/ leave of general stakeholders</i>			
11:00 – 12:30	Development of project concepts and roadmap for Akrotiri and Germasogeia sites	Outline a follow up project with Tasks, Partners and potential funding opportunities	Main objectives of the new project Main beneficiaries and stakeholders Tasks to be looked into and resources required Resources available and roles of partners Potential additional resources to be organized Programmes and funds which are available Next Steps and ToDos	Anika, Ronjon, Catalin, Kostas

Attendees of the replication workshop in Cyprus: Marinos Eliades (Cyprus Institute), Charis Samanides (CUT), Christiane Papoutsas (ECoE, CUT), Stylianos Hadjipetrou (ECoE, CUT), Viktoras Iordanou (Magnetar LTD), George Leventis (ECoE, CUT), Filio Ioulianos (WDD), Eleni Lolelli (ECoE, CUT), Popi Karaolia (NIREAS), Panos Papanastasiou (UCY), Charalampos Konstantinou (UCY), Konstantinos Panagiotou (ECoE, UCY), Catalin Stefan (TUD), Robert Schlick (TUD), Ronjon Heim (adelphi), Anika Conrad (adelphi).

Key outcomes

After presenting the solution concept including a set of suitable SMART-Control tools for the two selected sites (Akrotiri site and Germasogeia site), the participants provided the below feedback during the public event followed by a discussion round. The answers of the event participants were collected on Post-its (see Figure 7). A summary is given in the following.

1. Which topic is the **most relevant for you** and **why?** (a-d)

The most important topic for the participants was groundwater availability and quality, referring to complaints from the farmers about the bad smell of the water and the related fear of contamination through pathogens. With regard to groundwater availability, the mapping of future groundwater availability as well as drought monitoring and forecasts were particularly important to the participants.

2. Which topic is the most relevant for **Akrotiri or Germasogeia?** (a-d)

These topics are particularly interesting for the event participants for the transfer site Germasogeia. For the Akrotiri site, the focus was on saltwater intrusion and its control, which was not mentioned under question 1.

3. Please name **other topics** of interest for Akrotiri or Germasogeia?

Other topics relevant to the two transfer sites mentioned by participants were: Environmental benefits of MAR and the SMART Control concept, monitoring risks from heavy metal contamination and change in soil properties due to droughts and saltwater intrusion.

4. What is **your own recommendation** for a solution?

Improved monitoring of MAR sites is at the top of the participants' priorities, especially for pathogens, heavy metals and bacteria. Other measures not included in the SMART-Control approach were also mentioned, such as stricter regulations of water consumption and illegal wells as well as the introduction of smart irrigation systems.

The detailed solution concept and roadmap for the Akrotiri site can be found in *D7.3 Transfer concepts*.

Topics

- a) increased groundwater availability
- b) knowing more about future groundwater availability
- c) more health safety when using MAR water
- d) reduction of salt water intrusion

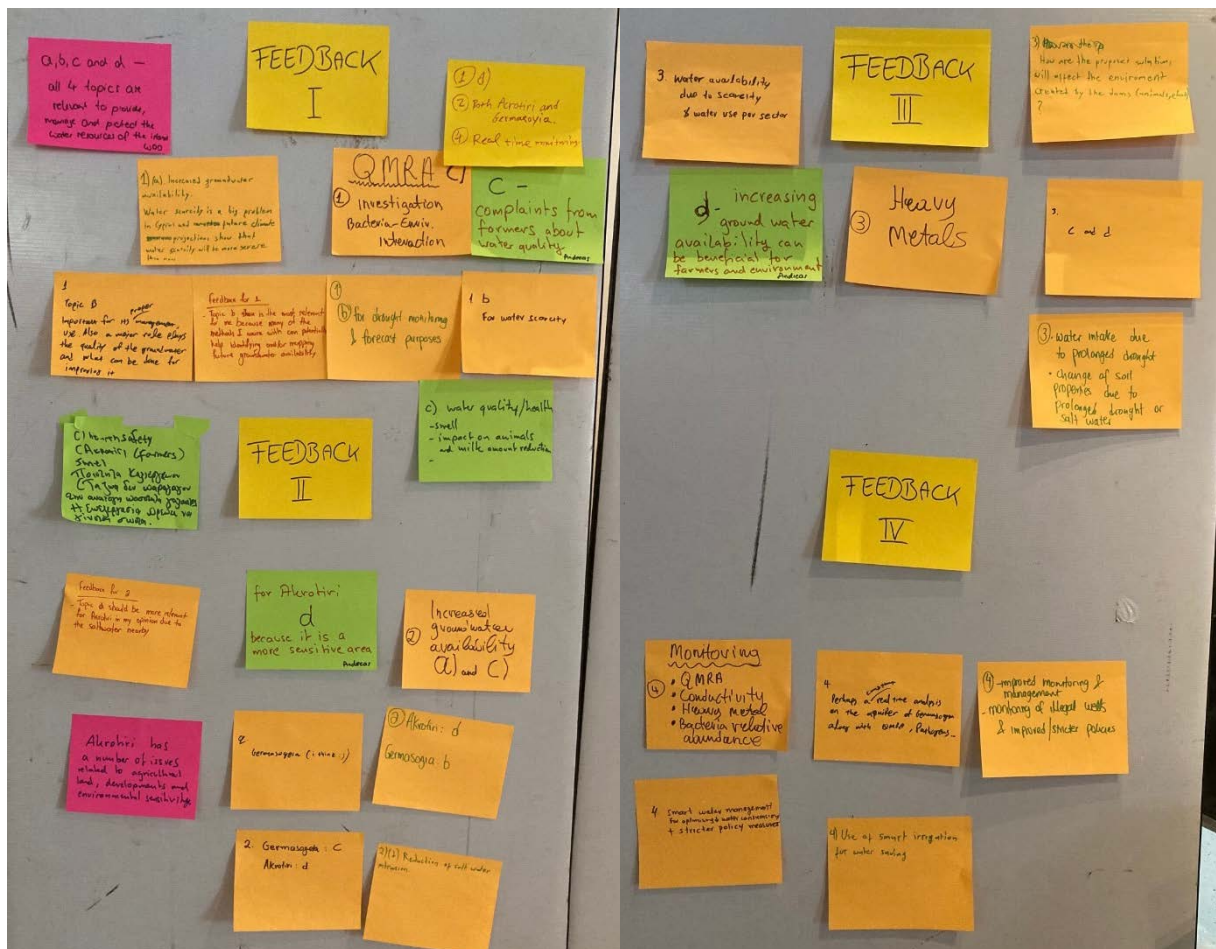


Figure 6. Feedback of stakeholders from Cyprus



Figure 7. Participants of the public event in Cyprus

3 REPLICATION MISSION TO BRAZIL

Timing: 11 – 21 January 2022

Attendees from the project team: Anika (adelphi), Ronjon (adelphi), Suzana (APAC/UFPE), Lucila (UFPE), Cristiano (UFPB)

3.1 AGENDA

Table 2. Agenda of the replication mission to Brazil

Date / Time	Programme	Objective	Detailed agenda	Resource person
10 January 2022				
17:45	Departure from Berlin to Recife			Anika (adelphi), Ronjon (adelphi)
11 January 2022				
10:40	Arrival in Recife			Anika (adelphi), Ronjon (adelphi)
11:00 – 17:00	Local preparations for the mission	The project team has set up on site enabling communication and meetings with local stakeholders	Getting the luggage, renting of a car, getting local money, buying SIM Card and installing an internet plan, checking in the hotel	Anika (adelphi), Ronjon (adelphi)
12 January 2022				
10:00 – 12:00	Meeting with project partner at the project pilot site in Recife	Updating on the current situation of the SMART-Control pilot	Site visit to the pilot plant and update on the current status of the installation of the sensors and the online monitoring results	Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)
12:00 – 13:30	Business Lunch Meeting			Suzana (APAC), Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)
14:00-17:00	Meeting with APAC	Updating and finalising replication options and arranging stakeholder meetings for the upcoming days	Discussion on the updates regarding the stakeholder constellation for the replication site ideas in Recife, especially the public market and the resorts Arranging meetings with the stakeholders for the next days	
13 January 2022				
10:00 – 12:00	Assessment of the replication site option: Public market of Afogados including meeting with the local management personell	First replication option in Recife assessed	Assessment of the status and viability of the public market as an replication option as well as the needs of the local stakeholders in regards to increasing water security	Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)
12:00 – 14:00	Lunch break			
14:00 – 16:00	Meeting with CSURB (Urban Services Authority of Recife)	Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at the public market of Afogados.	Gabriel Leitao, Diogo Azevedo, Romena Luna, Tyago Bianchi, José Ayverton (CSURB), Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)

Date / Time	Programme	Objective	Detailed agenda	Resource person
		SMART-Control products assessed	Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	
16:00 – 17:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	
14 January 2022				
08:00 – 10:00	Travel from Recife to Multo Alto			Anika (adelphi), Ronjon (adelphi)
10:00 – 12:00	Meeting with the maintenance manager of the Nannai resort at Multo Alto	Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and SMART-Control products assessed	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at the Nannai resort. Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	Fernando Oliveira (Maintenance manager of the Nannai resort), Anika (adelphi), Ronjon (adelphi)
12:00 – 13:00	Lunch break			Anika (adelphi), Ronjon (adelphi)
13:00 – 15:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	
15-16 January 2022: weekend				
17 January 2022				
10:00-12:00	Meeting with AESA (Executive Agency for Water Management of the State of Paraíba)	Replication options in Paraíba assessed, Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and SMART-Control products assessed	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at identified replication sites in Paraíba. Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	Beranger Arnaldo de Araujo (AESAs), Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
12:30 – 13:30	Business Lunch meeting			Cristiano (UFPB), Lucila (UFPE), Anika (adelphi), Ronjon (adelphi)
14:00 – 16:00	Meeting with project partner at the project pilot site in João Pessoa	Updating on the current situation of the SMART-Control pilot, Updating and finalising replication options and arranging	Site visit to the pilot plant and update on the current status of the installation of the sensors and the online monitoring results. Discussion on the updates regarding the stakeholder constellation for the replication site ideas in João Pessoa.	Cristiano (UFPB), Lucila (UFPE), René (AMPEC, sensor company, in charge of sensor installation at the project pilot site)

Date / Time	Programme	Objective	Detailed agenda	Resource person
		stakeholder meetings for the upcoming days	Arranging meetings with the stakeholders for the next days.	Anika (adelphi), Ronjon (adelphi)
16:00 – 17:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	Cristiano (UFPB), Lucila (UFPE), Anika (adelphi), Ronjon (adelphi)
18 January 2022				
10:00 – 12:00	Meetings with International office of UFPB (ACI)	Future collaboration opportunities are identified	Presentation of the replication potential of MAR and SMART-Control solutions in Paraiba, identification of synergies and evaluation of future collaboration opportunities with UFPB	Ana Berenice (ACI), Sandro Marden (ACI), Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
12:30 – 13:30	Lunch break			Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
14:00 – 16:00	Site visit and assessment of identified replication sites in João Pessoa: Convention Centre and Cultural Centre	Replication options in João Pessoa are assessed	Assessment of the status and viability of the sites as replication options as well as the needs of the local stakeholders in regards to increasing water security	Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
16:00 – 17:00	Internal wrap-up meeting	Finalising replication options for João Pessoa	Evaluation of assessed information and update of transfer concept	Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
19 January 2022				
09:00 – 17:00	Detailed elaboration of transfer concepts for the two selected sites	Fine tuning of the transfer concepts for presentation to the project partners	Contacting core stakeholders for missing information, compilation of final ideas and preparation of a presentation for the project partners	Anika (adelphi), Ronjon (adelphi), stakeholders
20 January 2022				
09:30 – 11:30	Internal debriefing meeting with project coordinator and project partners in Brazil	Planning of next steps for the cooperation	Presentation of identified transfer concept ideas and associated potential replication options and future collaboration opportunities, discussion with project team and fine tuning of the ideas, clarification of last open questions for the project ideas and planning of next steps	Suzana (APAC), Cristiano (UFPB), Lucila (UFPE), Catalin (TUD), Anika (adelphi), Ronjon (adelphi)
12:00 – 14:00	Travel from João Pessoa to Recife			Anika (adelphi), Ronjon (adelphi)
14:00 – 16:00	Meeting with the Environmental Secretary of Recife	Cancelled due to sick leave, instead preparation of meeting with Aries		
21 January 2022				
10:00 – 12:00	Meeting with Aries (Agency for Innovation and Strategy in Recife)	Future collaboration opportunities are identified	Presentation of the replication potential of MAR and SMART-Control solutions in Recife, identification of new replication options and synergies and evaluation of future collaboration opportunities with UFPB	Camila Lopes (Aries), Renato Martiniano (Aries), Anika (adelphi), Ronjon (adelphi)

Date / Time	Programme	Objective	Detailed agenda	Resource person
12:00 – 13:00	Lunch break			Anika (adelphi), Ronjon (adelphi)
13:00 – 15:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, future collaboration project ideas refined and internally discussed	Evaluation of meeting and future project ideas	
15:00	Preparations for departure	Departure prepared	Checking in, return of the car and checking in the luggage	Anika (adelphi), Ronjon (adelphi)
18:00	Departure from Recife to Berlin			
22 January 2022				
18:00	Arrival in Berlin			Anika (adelphi), Ronjon (adelphi)

3.2 KEY OUTCOMES OF THE ACTIVITIES IN PERNAMBUCO

3.2.1 Assessing the status of the SMART-Control pilot site in Recife

Date / Time	Programme	Objective	Detailed agenda	Resource person
12 January 2022				
10:00 – 12:00	Meeting with project site partner at the project pilot site in Recife	Updating on the current situation of the SMART-Control pilot	Site visit to the pilot plant and update on the current status of the installation of the sensors and the online monitoring results	Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)

Key outcomes

The pilot MAR scheme at the Landelino Rocha study site is still under construction. At the moment (January 2022), it consists of a multiple partially penetrating well with two pipes (a 2" in diameter, PVC) with screens at different heights (118-126 m and 127-136 m) connected to the same aquifer, Lower Cabo. This setup makes it possible to recover the water at a higher depth than it has been infiltrated. Another piezometer owned by the UFPE research team (2" in diameter, 145-177m intermittent) is available on the study site used to monitor the water level during recharge tests. Elements of the pilot system, which are being planned, are: a rainwater harvesting system, a water tank, and a sand filter for pre-treatment before infiltration.

Real-time sensors measure the water level in the monitoring well and both injection wells each 20 min. Results can be viewed at: www.ampeq.net/graf/est_mini_landelino.php as well as on the INOWAS platform. Unlike the other SMART Control pilot sites, the Landelino pilot site uses online sensors from a local company AMPEQ. The reason for this is the already existing very good cooperation between AMPEQ and the working group at UFPE as well as the ability to get local, fast support.

After the successful installation of the sensors, the team regularly monitors the water levels. It is noticeable that the development of the water level in the infiltration well differs from that in the monitoring well (see Fig. 9). This could indicate that both wells are separated by clay layers. In addition, the water level developments in both tubes of the infiltration well (simultaneous development) show previously inexplicable, abrupt increases, which cannot be attributed to rainfall events. Since both sensors show the same trend, it is assumed that another water source is causing this water level evolution. Investigations into this are ongoing.

A second recharge test is still being planned after the first one showed very low infiltration rates. Causes are suspected to be a blockage during the first infiltration test and a pipe size that is too small. The work team is planning infiltration tests on a well with a larger diameter in the immediate vicinity of the pilot plant. The search for a suitable well is still ongoing.

The real-time sensors of the pilot upload time series data on the INOWAS platform, where the results are visualised available for further interpretation and processing (Tool 10 Real time monitoring). The development of the groundwater model is in progress. As soon as it is uploaded on the INOWAS platform, an automatic update of the model via the real-time sensor data series is planned via Tool 20 Real time modelling.

Due to the early status of the pilot plant in Recife, the adelphi project team will not be able to show any results or live demonstrations to potential replicators. Presentations in replication meetings will be focused on the planned concept and envisaged impact of the pilot.

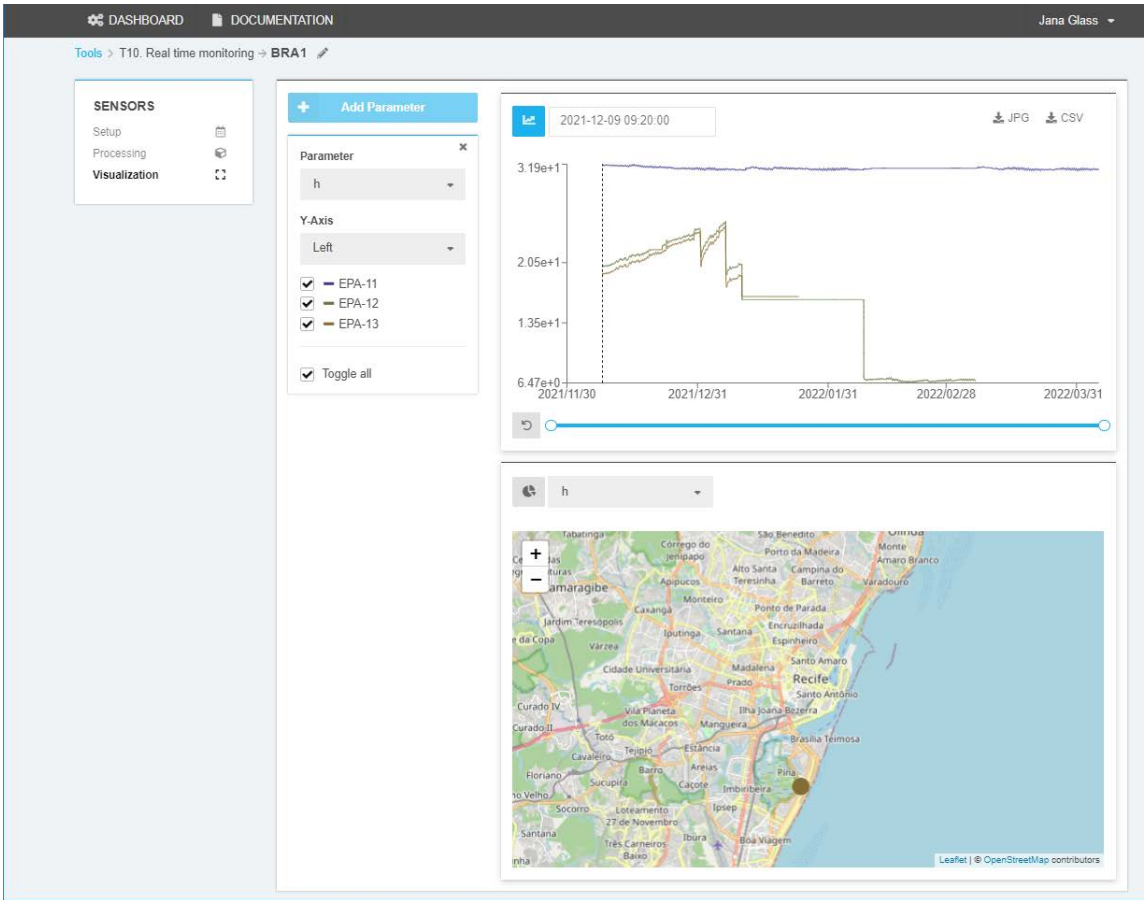


Figure 8. Evolution of the water level a the Landelino Rocha pilot site in Recife

3.2.2 Meeting with the climate and water agency of Pernambuco (APAC)

Date / Time	Programme	Objective	Detailed agenda	Resource person
12 January 2022				
14:00-17:00	Meeting with APAC	Updating and finalising replication options and arranging stakeholder meetings for the upcoming days	Discussion on the updates regarding the stakeholder constellation for the replication site ideas in Recife, especially the public market and the resorts Arranging meetings with the stakeholders for the next days	Updating and finalising replication options and arranging stakeholder meetings for the upcoming days

Key outcomes

APAC is the water and climate agency of Recife, responsible for planning and regulating the diverse use of water resources in the state of Pernambuco and strengthening integrated water resources management. With APAC's vast experience in water management issues of the metropolitan area of Recife and the strong local network, it was easy to set up meetings for the next few days. Transfer sites recommended by APAC were:

- Mercado de Afogados (reasons: large roofs with existing rain water harvesting infrastructure, existing cistern with 50 m³ storage capacity)
- Resorts in Multo Alto (reasons: due to very high water demand and saltwater intrusion into well fields, there is an urgent need for sustainable water management solutions)

APAC suggested to meet with the following stakeholders to develop further replication ideas and potential follow-up projects:

- CSURB (Urban Services Company of Recife in charge of organising the city's public markets and open fairs)
- Nannai (One of the largest beach resort in Muro Alto, south of Recife)
- Environmental Secretary of Recife (responsible for the coordination of the formulation, execution, evaluation and updating of the state's environmental and sustainability policies)
- ARIES (Agency for Innovation and Strategy of Recife, ongoing projects dealing with social inclusion, reduction of inequalities, environmental resilience of the city against climate change, e.g. *jardins filtrantes*: construction of plant filtration systems within the Caiara Park to treat part of the polluted water of the Cavouco Stream)

3.2.3 Public market of Afogados as replication option

Date / Time	Programme	Objective	Detailed agenda	Resource person
13 January 2022				
10:00 – 12:00	Assessment of the replication site option: Public market of Afogados including meeting with the local management personell	First replication option in Recife assessed	Assessment of the status and viability of the public market as an replication option as well as the needs of the local stakeholders in regards to increasing water security	Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)
14:00 – 16:00	Meeting with CSURB (Urban Services Authority of Recife)	Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at the public market of Afogados.	Gabriel Leitao, Diogo Azuevero, Romena Luna, Tyago Bianchi, José Ayverton (CSURB), Lucila (UFPE), Cleber (UFPE), Anika (adelphi), Ronjon (adelphi)

Date / Time	Programme	Objective	Detailed agenda	Resource person
		SMART-Control products assessed	Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	
16:00 – 17:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	

Key outcomes

Situational analysis: In the Recife Metropolitan Region (RMR), recent droughts and steady population growth, leading to an increase in water demand, have resulted in impacts such as groundwater depletion, saltwater intrusion, deterioration of water quality and ecological status, and potential land subsidence. To date, the Pernambuco State Water and Sewerage Company COMPESA can only meet about 85% of the RMR's water needs (Batista, 2015). In order to secure their own water supply, many residential buildings have drilled private wells (Cabral et al., 2008), leading to an even greater lowering of the water table, especially in densely populated neighbourhoods such as Pina (site of the SMART Control pilot area) and Afogados. The Afogados neighbourhood overlies the lower Beberibe aquifer, which also serves as a source of drinking water for public supply through COMPESA. To regulate the increasing stress on groundwater resources, MAR in combination with SMART-Control tools represents an attractive solution.

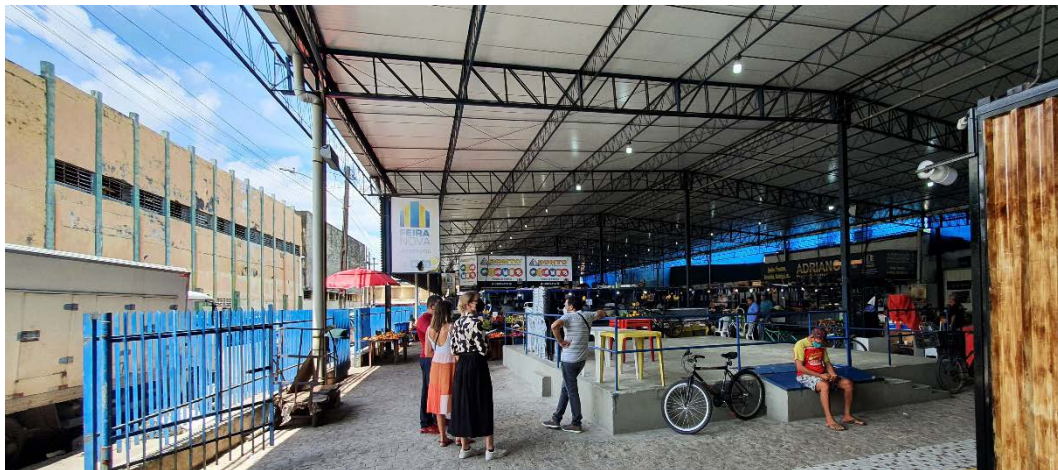


Figure 9. Cistern of the the new market of Afogados

Existing infrastructure supporting MAR implementation: The two public markets of Afogados with their large roof area of over 31,501 m² are ideal as MAR sites. The collected rooftop rain water would be sufficient to cover the water demand of 2900 m³ of the markets (data from the CSURB) and furthermore replenish the local aquifer Beberibe. The new public market of Afogados already captures its rainwater which is intended to be stored in a partitioned 50 m³ cistern, which has just recently been constructed. To date, the water is being discharged unused onto the street, from where it flows into the canalisation leading into the sea. The reason for this, given by a local caretaker at the market, is the lack of a purification stage for the collected rainwater to make it safe for use in the public market (cooking, etc.). As per him, current plans are to use the water for the sanitary facilities. He further mentions that there are plans for installing pretreatment systems to further purify the collected rainwater and then use it for different purposes. Currently the cisterns are filled with water from the public water supply, which though is limited and does not cover the entire requirements of the market.

Key data on replication idea

Table 3. Key data on replication idea for the Public Markets of Afogados

Replication site category	1 - no existing MAR sites yet, but MAR is planned
Entry-level feasibility assessment according to the Australian guidelines	
Intended water use - Is there an ongoing local demand or clearly defined environmental benefit for recovered water that is compatible with local water management plans?	<p>YES –</p> <p>Needs of and benefits for the Public Market of Afogados:</p> <ul style="list-style-type: none"> • Securing water availability in the market for hygienic purposes (currently there is only water once or twice in the week which is stored in a cistern) • Mitigating seawater intrusion/protecting existing wells in the old market <p>public needs and benefits:</p> <ul style="list-style-type: none"> • Minimising flood events in the area • Demonstrating MAR as a safe and reliable solution with SMART-Control framework to stimulate further MAR projects in Brasil/Pernambuco
Source water availability and right of access - Is adequate source water available, and is harvesting this volume compatible with catchment water management plans?	YES - The two public markets of Afogodas have large roofs with an area of over 31,501 m ² , enabling to collect a volume of rainwater that covers the water needs of 2900 m ³ of the markets (data from the CSURB) and in addition contribute to recharge the aquifers for other long term benefits such as reducing risks of subsidence, providing water for other water users, ecological benefits, reducing saltwater intrusion etc.
Hydrogeological assessment – Is there at least one aquifer at the proposed managed aquifer recharge site capable of storing additional water?	YES – the lower Beberibe aquifer serves as the main groundwater source for drinking water for the public water supply as well as being exploited by many private wells. Due to the increasing demand for water, the Beberibe aquifer is subject to groundwater over-exploitation, which provides capacity for recharge water.
Hydrogeological assessment – Is the project compatible with groundwater management plans?	YES – CSURB and APAC are supporting a MAR project at the Public Market of Afogados
Space for water capture and treatment - Is there sufficient land available for capture and treatment of the water?	YES – The markets are located in a densely populated neighbourhood of Recife, but according to the maintenance manager of the market and CSURB, there is enough space for a filter system to pre-treat the rainwater, and ASR wells. A cistern with 50m ³ is already in place (could serve as a brief buffer system before recharge).
Capability to design, construct and operate - Is there a capability to design, construct and operate a MAR project?	Local maintenance team did not yet work with MAR, would need training
Suitable SMART-Control approach	
Local needs/benefits → SMART-Control tools	<ol style="list-style-type: none"> 1. Improved MAR planning → <i>T06 MAR method selection</i> and <i>T11 MAR model selection</i> 2. Improved groundwater resources management and planning, groundwater availability assessment → <i>T03 Numerical groundwater modelling and optimization</i> and <i>T07 MODFLOW model scenario manager</i> 3. Knowledge on required measures of MAR operation to reduce seawater intrusion → <i>T09 Simple saltwater intrusion equations</i>

Key outcomes of the meeting at CSURB

CSURB is practically interested in increasing and optimising the water supply in its markets. Referring to prior discussions with the project team, CSURB had now installed a rainwater catchment system at the new market and is currently implementing its full usage (as already informed by the local caretaker). Even if the rainwater is captured in the newly constructed cistern, there would still be plenty of additionally available rainwater for which there is currently no usage foreseen and which would be drained into



Figure 10. Meeting with CSURB

the sea. The option of recharging the groundwater with this surplus rainwater would be a good idea, especially as it could also address the decreasing quality and availability of fresh water from the wells in the old market. For CSURB it would be very interesting to look into the costs and benefits of a MAR installation. Given the already existing infrastructure for the collection and temporary storage of water and also the existing wells, not much additional equipment might be required for a basic system which makes this idea very attractive. CSURB requested the team to make a detailed feasibility study including a cost benefit analysis. The SMART Control team mentioned that they were interested in looking at the feasibility of this system in the framework of a research project. CSURB is generally interested in working together to improve water security in Recife as part of a research project. MAR offers a very good solution for this, for which they are keen to make Recife's public markets available as possible demonstration sites. CSURB also mentioned further markets which could be looked at, including: Cais de Santa Rita.

3.2.5 Nannai resort as replication option

Date / Time	Programme	Objective	Detailed agenda	Resource person
14 January 2022				
08:00 – 10:00	Travel from Recife to Muro Alto			Anika (adelphi), Ronjon (adelphi)
10:00 – 12:00	Meeting with the maintenance manager of the Nannai resort at Muro Alto	Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and SMART-Control products assessed	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at the Nannai resort. Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	Fernando Oliveira (Maintenance manager of the Nannai resort), Anika (adelphi), Ronjon (adelphi)
12:00 – 13:00	Lunch break			Anika (adelphi), Ronjon (adelphi)
13:00 – 15:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	

Key outcomes

- adelphi introduces the objectives and approaches of the SMART-Control project and the meeting including the objective of MAR, the SMART-Control tools and how they can help reduce associated risks of MAR systems
- Fernando Oliveira states to have general interest in the SMART-Control solutions and approaches presented and provides insight into the situation at Nannai resort:

Challenge

- Nannai has so far been able to meet its water demand mainly with groundwater. However, the resort is increasingly struggling with the problem of GW salinisation. One of the three wells (well 1) had to be closed due to high salt concentrations (8000 mg/L TDS). The other wells, further from the coast, are still relatively unaffected (250 mg/L TDS), but only located about 200 m from the third well (possible extraction rates: 15 m³/h (well 1), 8 m³/h (well 2), 15 m³/h (well 3))
- the rainwater is collected from almost all roofs, filtered and used for irrigating the gardens and for cleaning
- Well water is used for most other purposes
- To compensate for the loss of the third well and increasing water demand, Nannai buys from the public water supplier COMPESA (approx. 15 m³/dia for 15.5 R\$/m³) This water is specifically used for cooking, ice making and laundry
- the following solution strategies are considered so far to increase water availability and keep water purchases from COMPESA low:
 - Dilution of the brackish GW with produced water from the other wells via a cistern
 - Drilling of a new well
 - Increasing rainwater harvesting and treatment

MAR as a solution to address the challenge

- the excess water collected from these roofs could be stored via the unused third well in the aquifer to avoid an enlargement of the cistern and to build a freshwater bubble underground and could be abstracted again when needed.
- Existing monitoring system: currently hydro-geological variables such as water level and salinity are measured manually, which can be enhanced by adding suitable online sensors and connecting these to the SMART-Control platform to form a real-time monitoring and control system.

Key data on replication idea

Table 4. Key data on replication idea for the Nannai resort

Replication site category	1 - no existing MAR sites yet, but MAR is planned
Entry-level feasibility assessment according to the Australian guidelines	
Intended water use - Is there an ongoing local demand or clearly defined environmental benefit for recovered water that is compatible with local water management plans?	YES – Needs of and benefits for the Nannai resort: <ul style="list-style-type: none"> • Increasing water availability through the use of currently unused rainwater resources • Reduce the risk of salination of the other 2 wells by using the third well as an ASR well building a freshwater barrier • in the worst-case scenario that all three wells become saline and groundwater can no longer be used, Nannai would incur the following costs by purchasing COMPESA water as compensation: 5000 m³ x 15.5 R\$/m³ = 77500 R\$
Source water availability and right of access - Is adequate source water available, and is harvesting this volume compatible with catchment water management plans?	YES - rainwater captured from the roofs of the Nannai resort not yet used: 2750 m ³ (roof area: 1,375 m ² x about 2000 mm rainfall/year)

Hydrogeological assessment – Is there at least one aquifer at the proposed managed aquifer recharge site capable of storing additional water?	YES – Cabo aquifer (?) (well profiles are available). Due to the increasing demand for water, the Cabo aquifer in Multo Alto is subject to groundwater over-exploitation, which provides capacity for recharge water.
Hydrogeological assessment – Is the project compatible with groundwater management plans?	YES – APAC are supporting a MAR project in Multo Alto
Space for water capture and treatment - Is there sufficient land available for capture and treatment of the water?	YES - Cisterns (as a buffer system), filters and a well available for recharge purposes are already in place
Capability to design, construct and operate - Is there a capability to design, construct and operate a MAR project?	Local maintenance team did not yet work with MAR, would need training
Suitable SMART-Control approach	
Local needs/benefits → SMART-Control tools	<ol style="list-style-type: none"> 1. Improved MAR planning → <i>T06 MAR method selection and T11 MAR model selection</i> 2. Improved groundwater resources management and planning, groundwater availability assessment → <i>T03 Numerical groundwater modelling and optimization and T07 MODFLOW model scenario manager</i> 3. Knowledge on required measures of MAR operation to reduce seawater intrusion → <i>T09 Simple saltwater intrusion equations</i>

Agreed next steps

- Fernando Oliveira is interested in a collaboration, but would not pay for the installation of a MAR project, but makes data and his premises available for research activities.
- He offered to provide the following data (we have specified our requirements a bit more):
 - Lithological profile of the three wells
 - Hydro-geological data including permeability, conductivity, etc.
 - Water demand and consumption pattern of the last 5 years
 - Precipitation data of the last 10 years
 - Water quality data from the wells (TDS/elect. Conductivity) for the last 10 years
- On the basis of this data adelphi could look into elaborating a concept
- Both Nannai and adelphi would look into finding funds for future project which could look into elaborating a feasibility study and a pilot installation at the site.

3.2.6 Meeting with ARIES

Date / Time	Programme	Objective	Detailed agenda	Resource person
21 January 2022				
10:00 – 12:00	Meeting with Aries (Agency for Innovation and Strategy in Recife)	Future collaboartion opportunities are identified	Presentation of the replication potential of MAR and SMART-Control solutions in Recife, identification of new replication options and synergies and evaluation of future collaboration opportunities with UFPB	Camila Lopes (Aries), Renato Martiniano (Aries) Anika (adelphi), Ronjon (adelphi)

Key outcomes

ARIES is a non-profit organisation for innovation and strategy, with the aim of social inclusion, reducing inequalities and contributing to the city's environmental resilience. Vision: to make Recife liveable in 2037. They work closely together with the prefeitura, academia, and citizens and see citizen participation as one of the pillars for the success of their projects.

ARIES coordinates and implements currently three main projects with several small pilot sub-projects: Plano Recife 500 anos, Primeiro a infancia and CITinova.

CITinova, conducted in São Paulo (SP), Brasília (DF) and Recife (PE), is a national project focused on developing a platform for sustainable cities, investing in innovative technologies and sustainable urban planning. Aiming for an inclusive and sustainable future, the CITinova project uses innovative technological solutions to help solve urban problems, such as river pollution, urban microclimate monitoring and the need for social housing policy tools.

Project examples:

Filtration gardens - Construction of filtration gardens in Caiara Park to purify part of the water of the Cavouco stream polluted by sewage discharges. The filtration gardens are a nature-based solution that performs a phytoremediation process to clean polluted water. The purified water will flow into a lagoon recharging the aquifer.

Solar boat system: Technical and financial feasibility study on the operation of a solar boat system on the Capibaribe River providing a transport system for citizens between the urban areas of the Parque do Caiara in Iputinga and the Murillo La Greca Museum in Parnamirim. However, they face problems finding a private company that wants to take over the boats after the project ends. So far, the Prefeitura has shown no interest in financing and taking over.

Another project looks at bundling and processing all the authorities' city data on one platform for better and targeted use.

Financed by third-party funds (e.g. Citinova via Fundo Global para o Meio Ambiente (GEF)).

ARIES is generally interested in collaborating in an international project. They see MAR as a very good solution for Recife and they like the idea of using the public markets of Afogados as demonstration sites. When applying for funding, they point out the importance to specify the beneficiaries and how many families will benefit, in order to best promote the project idea. An upcoming call under Water4All seems to be very suitable for a first cooperation. However, in terms of project budget, Recife can only be one case study of many and others would need to be identified.

ARIES and adelphi agree to stay in touch and to undertake a follow-up meeting with CSURB and the SMART Control team as soon as the Water4all call is published to develop a project proposal.

3.3 KEY OUTCOMES OF THE ACTIVITIES IN PARAÍBA

3.3.1 Meeting with the Water Agency of Paraíba (AESA)

Date / Time	Programme	Objective	Detailed agenda	Resource person
17 January 2022				
10:00-12:00	Meeting with AESA (Executive Agency for Water Management of the State of Paraíba)	Replication options in Paraíba assessed, Decision maker responsible for replication option engaged and interested in cooperation, application potential and scope of MAR and SMART-Control products assessed	Presentation, discussion and evaluation of the application potential, benefits and scope of MAR and the SMART-Control products to increase water security and reduce risks associated with MAR at identified replication sites in Paraíba. Demonstration of the benefits of SMART-Control through the pilot plants in Brazil.	Beranger Arnaldo de Araujo (AESA), Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)

Key outcomes

- AESA is in general interested in an applied MAR project including the installation of a MAR pilot.
- Recommended sites for MAR:
 - o Convention Centre (entire roof equipped with rainwater harvesting infrastructure; the construction of new resorts is planned in the surrounding area, which will have to demonstrate sustainable resource consumption according to requirements of the city (this concerns the consumption of energy, water, etc.), in addition, a pool for touristic purposes (artificial surfing, waving pool) is planned to be constructed in May 22, which needs a lot of water
 - o Cultural Centre (entire roof equipped with rainwater harvesting infrastructure, use the water for the fish)
- Ongoing national call for projects that carry out a study on the natural recharge of the aquifer throughout the coastal zone. Although recharge of the aquifer is not explicitly mentioned, this call could be helpful for an upcoming MAR project as more information on the hydrogeology and inflow will be generated
- **Needs for MAR:** Since last year, AESA has had to restrict water supply in the inland areas because of the drought. The regions most affected were: Areia and Bananeiras, whose water supply was supplemented with water tanks. In João Pessoa, the water resources are still sufficient for the time being, but this can change quickly with the increase in planned hotel complexes and the expansion of the city, so that a sustainable water management is already needed. The dam's infrastructure was built to supply 50% of the current population. AESA is interested in automating the MAR systems.
- **Potential water sources for MAR:** A canal system is used to fill the reservoirs. Once the reservoirs are filled, the surplus water would be available for recharging the aquifers.
- **Hydro-geological conditions:**
 - o Water availability: UFPB has a good monitoring programme including 40 wells measuring groundwater level data since 2018; rainwater data; but they do not know the natural recharge rate of the aquifer. CAGEPA, the regional water supplier of Paraíba (such as COMPESA of Pernambuco) uses groundwater in some areas at the coast. However, UFPB thinks that they do not monitor these resources. The data availability is poor. Last study was conducted in 2006. They have superficial information in the hydrogeology, but not on the aquifer flow, inflow and outflow. It would be interesting to study the groundwater availability to conclude on sustainable extraction patterns and needs for groundwater recharge. A regulation exists, but still many wells are not monitored, unknown how much water they withdraw.
 - o Water quality: In most of the areas, the unconfined aquifer has a good water quality. Seawater intrusion is mainly unknown: some wells have salinity problems, but they do not know how many and since when.
 - o Geology: Big sedimentary area inland to the west, Campina Grande, drought since 10 years.
- Mentioned key stakeholders by AESA: CAGEPA (water utility), SUDEMA - Superintendent of Environment Administration, AESA, SEIRHMA (Secretariat for Infrastructure, Water Resources and Environment), CINEP (Industry), FAPESQ-PB → in order to approach the stakeholders, they could help us, but would need to have a specific ppt with specific project ideas.
- Managed aquifer recharge sites in Brazil are currently limited to underground check dams. Recently, south east of Brazil faced water scarcity for 4 months. Since electricity production depends on dams, this caused problems all over the country, as far as the northeast.
- **Conclusion:** AESA is interested in collaborating on a project related to MAR, where the activities could be linked to the large study that will be conducted soon. Cristiano is interested in submitting a proposal to this call in which he would like to include MAR.

3.3.2 Assessing the status of the SMART-Control pilot site in Paraíba

Date / Time	Programme	Objective	Detailed agenda	Resource person
17 January 2022				
14:00 – 16:00	Meeting with project site partner at the	Updating on the current situation of the SMART-	Site visit to the pilot plant and update on the current status of the	Cristiano (UFPB), Lucila (UFPE),

Date / Time	Programme	Objective	Detailed agenda	Resource person
	project pilot site in João Pessoa	Control pilot, Updating and finalising replication options and arranging stakeholder meetings for the upcoming days	installation of the sensors and the online monitoring results. Discussion on the updates regarding the stakeholder constellation for the replication site ideas in João Pessoa. Arranging meetings with the stakeholders for the next days.	René (AMPEC, sensor company, in charge of sensor installation at the project pilot site) Anika (adelphi), Ronjon (adelphi)
16:00 – 17:00	Internal wrap-up meeting of the day	Minutes of the meeting finalised and shared with stakeholder, transfer concept updated	Evaluation of assessed information and update of transfer concept	Cristiano (UFPB), Lucila (UFPE), Anika (adelphi), Ronjon (adelphi)

Key outcomes

The João Pessoa case study uses an Aquifer and Storage (AS) approach, collecting rainwater from the roof of the Hydraulics laboratory at the Federal University of Paraíba (UFPB) and recharging it by gravitational force into the unconfined aquifer, Barreiras Formation, using injection wells. A water tank is used as interim storage for the rainwater. The two injection wells have the following dimensions: 6 inches diameter and 42 meters depth, with a 12-meter filter interval. In contrast to the beginning of the project, four additional piezometers were installed to the 2 existing ones to monitor the pilot recharge site. AMPEQ sensors were successfully installed and connected to the SMART-Control system.



Figure 11. SMART-Control pilot site in Joao Pessoa: starting the infiltration

During the visit of adelphi, a short infiltration test was carried out to observe the response of the water levels in the subsurface. However, for an accurate description of the hydro-geological characteristics of the site as well as infiltration rate and GW-flow, a longer test and investigation of the water levels is necessary. Due to the early status of the pilot site, no further SMART control tools have been tested on it yet. The development of a GW model is planned for the next six months using the SMART-Control tool Nr. 03.

The site is well suited as an experimental site to study possible recharge and recovery patterns for other sites under similar conditions.

3.3.3 Meeting with the International Office of UFPB (ACI)

Date / Time	Programme	Objective	Detailed agenda	Resource person
18 January 2022				
10:00 – 12:00	Meetings with International office of UFPB (ACI)	Future collaboration opportunities are identified	Presentation of the replication potential of MAR and SMART-Control solutions in Paraíba, identification of synergies and evaluation of future collaboration opportunities with UFPB	Ana Berenice (ACI), Sandro Marden (ACI), Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)

Key outcomes

The International Office of UFPB (ACI) primarily supports the university in building networks with other universities, arrange agreements, student exchanges etc. There are not involved in the development of new research proposals nor do they have an overview of possible funding opportunities. Options for initiating a cooperation between the TU-Dresden and the UFPB were discussed and contacts shared. From the conversation it emerges that there is little overlap between the mandate of ACI and the objective of the replication activities, which is why no further interaction is planned in the framework of D7.3.

3.3.4 Convention Centre and Cultural Centre of João Pessoa as replication option

Date / Time	Programme	Objective	Detailed agenda	Resource person
18 January 2022				
14:00 – 16:00	Site visit and assessment of identified replication sites in João Pessoa: Convention Centre and Cultural Centre	Replication options in João Pessoa are assessed	Assessment of the status and viability of the sites as replication options as well as the needs of the local stakeholders in regards to increasing water security	Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)
16:00 – 17:00	Internal wrap-up meeting	Finalising replication options for João Pessoa	Evaluation of assessed information and update of transfer concept	Cristiano (UFPB), Anika (adelphi), Ronjon (adelphi)

Key outcomes

While searching for suitable locations for MAR demonstration sites in João Pessoa, the Cultural Centre and Convention Centre appeared to be very suitable due to their large roof areas and existing rainwater harvesting infrastructure (sites have been also recommended by AESA). At both sites, all collected rainwater is already used for primarily decorative purposes: for outdoor deco ponds or indoor fish ponds. Interestingly, facilities at the Convention Centre indicated that infiltration of excess rainwater was originally planned to recharge the aquifers (see Figure 13b). At the moment of the visit, the basins were not filled with water and the system seems abandoned.

UFPB maintains a well at the Convention Centre, but in the unconfined aquifer and not in the confined aquifer, which would be filled by the existing recharge system.

In conclusion, sufficient water is collected and available at both sites. The current uses indicate that there is no water shortage yet. Should this situation worsen, these two locations are probably very well suited for the implementation of a MAR system. Especially the Convention Centre with its proximity to planned hotel resorts with golf courses and large pool facilities.



Figure 12. Convention Centre of Joao Pessoa: a) Large roofs with deco ponds; b) infiltration system

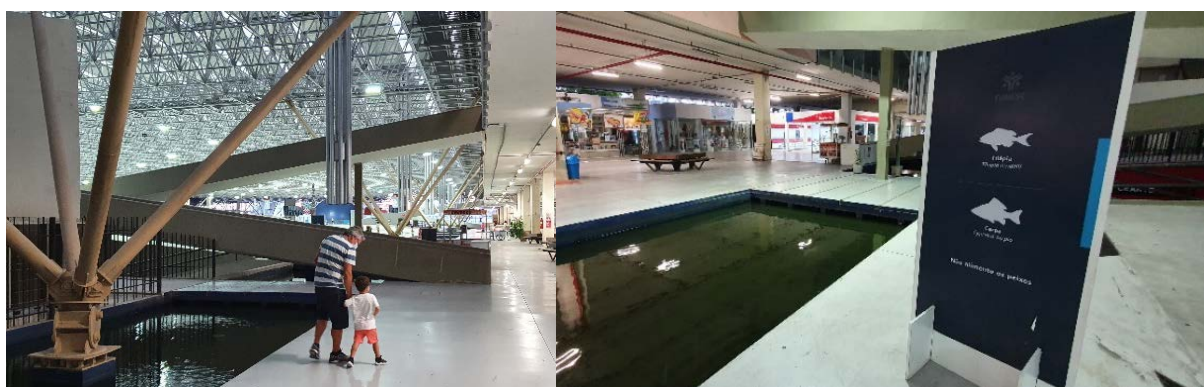


Figure 13. Cultural Centre Joao Pessoa: a) Rainwater harvesting system incl large roof with piping system; b) Indoor fish ponds using rainwater

3.4 INTERNAL DEBRIEFING MEETING

Date / Time	Programme	Objective	Detailed agenda	Resource person
20 January 2022				
09:30 – 11:30	Internal debriefing meeting with project coordinator and project partners in Brazil	Planning of next steps for the cooperation	Presentation of identified transfer concept ideas and associated potential replication options and future collaboration opportunities, discussion with project team and fine tuning of the ideas, clarification of last open questions for the project ideas and planning of next steps	Suzana (APAC), Cristiano (UFPB), Lucila (UFPE), Catalin (TUD), Anika (adelphi), Ronjon (adelphi)

Key outcomes

Promising replication sites in Brazil:

The site partner in Brazil and adelphi present the key outcomes and the most promising MAR replication sites to the SMART-Control team (Public Market Afogados and Resort Nannai, see more information in section 3.1.3 and 3.1.5). Both most promising sites are located in Recife. AESA's recommendations for MAR sites in João Pessoa (Convention Centre and the Cultural Place José Lins do Rego) generally showed promising conditions for implementing MAR, as explained in more detail in section 3.2.1, but the need for a MAR site does not yet exist as water is available beyond the need. The situation is different in the areas of Bananeiras and Areia (inland from Paraiba), where they suffer water scarcity and supply had to be limited last year. However, the project team has little information on these regions regarding geohydrology and water availability. A site visit to these areas was in the framework of the replication missions not possible due to the short time available. Possibly the state master plan has information.

Q&A Discussion

- a future demonstration project should have socioeconomic relevance and clear benefits of the MAR system
- a feasibility study including modelling could answer the question of benefits for the enduser
- there could generally be two options for the scope of a site: site specific benefits for the main user, or a bigger scheme with different stakeholders involved (e.g. like in Japan)
- To have a greater impact, a project should go beyond a demonstration project and address governance, funding and incentives for MAR.
- Decrete 20.423 from Pernambuco state has a provision to provide incentive with lowering public taxes for artificial recharge.

- Legislation on setting up MAR systems is currently weak and would require stronger regulation for enabling smooth operation of MAR systems, such as licensing system for MAR, technical guidelines for MAR, standards to be developed for MAR systems.
- DSS for surface water rights is been developed funded by ANA
- Guidelines for groundwater are developed by LNEC for Pernambuco
- Currently a study on water availability will be setup in Paraiba
- Decision support system for groundwater licensing would be important for APAC

Stakeholder roles:

- APAC/AESA are the key stakeholders, e.g. it gives licenses for building wells
- APAC does not suggest new laws, this is the scope of the groundwater advisory board

Funding opportunities

- AESA has funds for supporting projects, projects can be suggested to the state water council,
- APAC has a similar more limited option for watershed communities

Brazil is eligible in all European calls:

- European green deal initiative – improve knowledge and capacities to cope with climate, calls up to 20M€, very large consortia with wide geographical coverage
- Horizon 2050, next submission in in Feb 2022, possibly next submission Feb 2023

Smaller transnational calls:

- Eranet: subdivision for Latin America and Caribic (current call has ended), probably new calls could come up
- Water JPI: launched new call in December, Transnational Call 2022, pre announcement water4all: management of water recourcses for increased resilience, adaptation and mitigation to hydroclimatic extreme events, first project idea to be submitted in March
- BMBF international office might have some options for supporting
- PHD funding in Dresden in a sandwich programme, deadline by mid of February
- Possibly a cooperation between universities could enable more academic exchange

Next Steps

To Dos	Responsible
Assess the potential support and role of ARIES	adelphi
Elaborate D7.3 Transfer Concept for Brazil based on the assessed information and outcomes of this discussion	adelphi
Screen for suitable calls that are applicable to the ideas discussed	all
Follow the development of the current study of water availability in Paraiba	UFPB
Consultation with the Minister of Science, Technology and Innovation on the implementation of existing incentive provision on MAR	Lucila
The next meeting could be organised during the second replication mission to Cyprus in May 2022 participation of TUD, adelphi, site partners, UFPE (?), UFPB (?)	all

4 CONCLUSION

The main take away from the replication missions is that there is great interest and need in SMART-Control approach and MAR systems in general. The SMART-Control approach is seen to be very useful in optimising the operation of MAR systems. SMART-Control components that were most interesting to stakeholders in Brazil and in Cyprus are: real-time monitoring and modelling as well as support in decision-making and planning with the scenario manager. The risk assessment and water quality prediction with QMRA and residence time is seen to be very useful at the existing sites in Cyprus. Furthermore, representatives of the Cyprus Geological Survey emphasized the necessity of combining real-time data and contaminant modeling in groundwater systems to address pollution issues that exist in both MAR sites in Cyprus (Akrotiri, Ezousa), such as sea-water intrusion and nitrification. The SMART-Control approach already supports the integration between real-time data and physically-based models for predicting the spatio-temporal evolution of both the groundwater flow and contaminants.

The most promising site for the replication of the SMART-Control approach including its tools in Cyprus is the existing MAR site at Akrotiri due to its importance for the water supply and the challenges, which can be addressed with an optimised MAR system. The Public Markets of Afogados is the most promising MAR replication site in Brazil as the stakeholders are eager on setting up a MAR system and the infrastructural prerequisites are given. The missions have collected relevant information regarding funding opportunities and have identified the core stakeholders to be involved in future research projects. For both sites, transfer concepts will be developed in D7.3. with more technical and socio-economic details for the development of project proposals. For Cyprus a follow-up replication mission is planned for conducting further bilateral meetings and assessing additional sites.

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