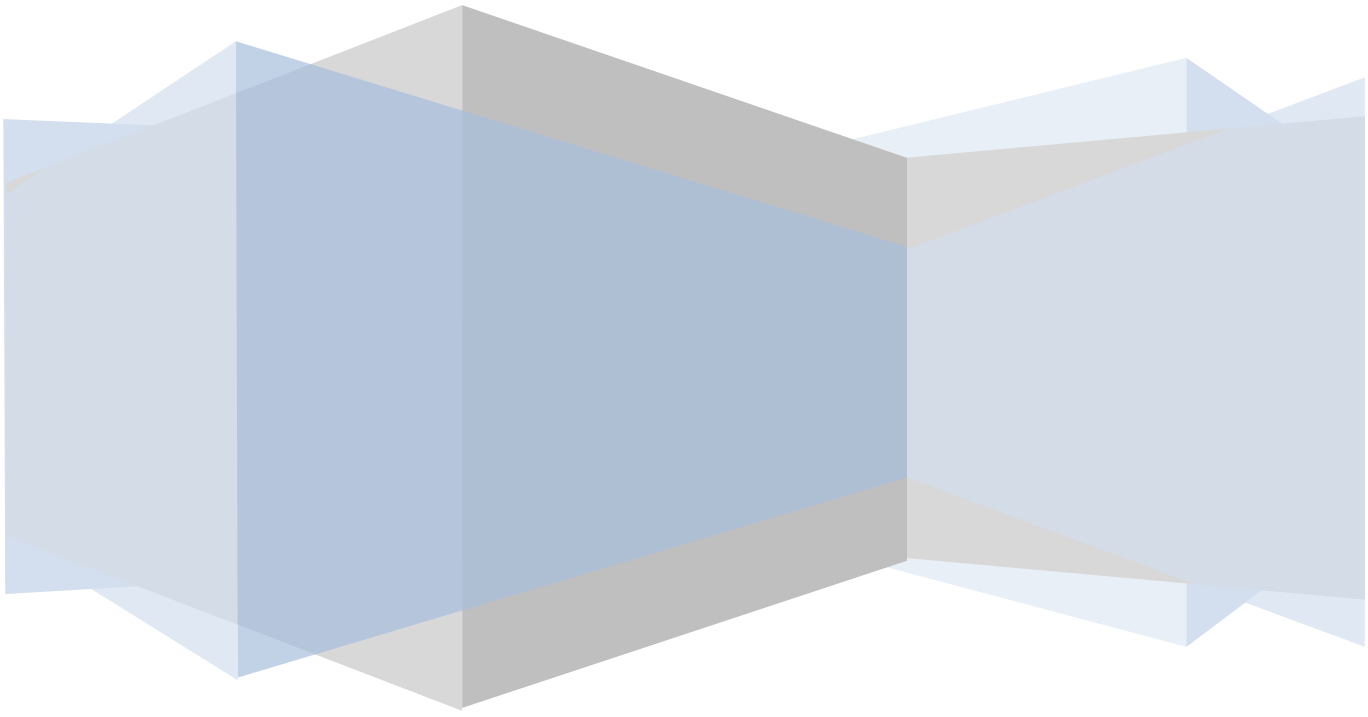
Mid-Term Progress Report

Water Joint Programming Initiative 2018 Joint Call

Closing the water cycle gap - Sustainable management of water resources



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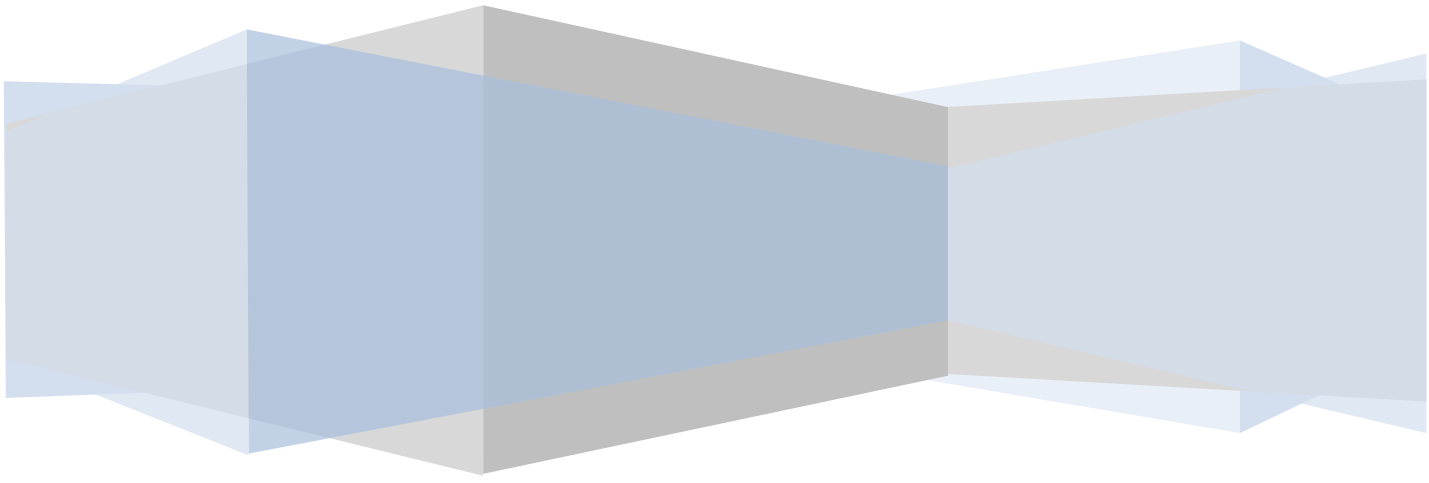
Research-based Assessment of Integrated approaches to Nature-based SOLUTIONS
(RainSolutions)



Research-based Assessment of Integrated approaches to Nature-based SOLUTIONS (RainSolutions)

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Project Website: https://www.rainsolutions.info
Project code: WaterWorks2017-RainSolutions

Duration of project: 3 years
Start date: 1 April 2019 End date: 30 March 2022

Period covered by this report: 1 April 2019 to 30 October 2020

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Publishable Summary

The objectives of the Water JPI project "Research-based Assessment of Integrated approaches to Nature-based SOLUTIONS (RAINSOLUTIONS)" are (a) to identify stakeholder and urban ecosystem needs to inform planning/design; (b) to review and capitalize upon existing experiences of good practices; (c) to simulate the impact of climate variability and existing urban infrastructure on NBS within scaled pilot laboratory and field installations; (d) to develop an integrated indicator system for the evaluation of key NBS in terms of closing the water quantity and quality gap addressing also socio-economic aspects; (e) to map ecosystem services delivered by NBS for an evaluation of the best technology to implement in different urban contexts to support sustainable water management; (f) to create a NBS planning and design framework supported by machine learning to generate recommendations; and (g) to disseminate the self-sustainable web-based framework in collaboration with national stakeholders and communicate the project impact.

The output is of scientific, innovative and societal nature. Scientific: RAINSOLUTIONS delivers new knowledge and related tools and guidelines for innovative planning and assessment of NBS as part of sustainable water systems. Targeted knowledge products will be developed for the different audiences informing them about the benefits of NBS and the proposed evidence-based framework. The platform will also facilitate expert knowledge exchange.

A reference framework for future solution is being deployed. This will facilitate the growth of small businesses providing NBS and services, and creating new local green jobs in the process.

Benefit are via substantially improved quality of life and well-being due to innovative NBS used which, in turn, will help reduce the risk of flooding and droughts whilst restoring urban ecosystems and adding to the amenity value of the urban environment.

The following partners are part of RAINSOLUTIONS: Lund University (Sweden), University of Johannesburg (South Africa), University of Pretoria (South Africa), VESI Environmental Ltd. (Ireland), Federal University of Technology (Brazil), Técnica y Proyectos S.A. (Spain), Oslo Metropolitan University (Norway), Wageningen University and Research (The Netherlands), University of Tartu (Estonia) and Danube Delta National Institute for R&D (Romania).

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Work Performed and the Results achieved during the reporting period

a) Scientific and technological progress

Lund University

The research project focuses on the potential impact of climate change on wetland ecosystems; both natural (peatland) and constructed wetlands as well as lakes receiving the corresponding outflows of both systems. For this purpose, an experiment was conducted on wetland and linked lake mesocosms in four climate chambers simulating four different climate scenarios including current climate, RCP 2.6, RCP 4.5 and RCP 8.5.

The mesocosms were monitored for various parameters to investigate the responses of the wetland and the associated lakes to climate change in terms of water quality and climate change mitigation. For this purpose, hydrological, physical and chemical parameters were measured in all systems. In addition, the carbon dioxide flux was measured in the peatland mesocosms (natural wetlands) as well as algae growth in the lakes. All the data were generated over the past three years, although the time periods for different data sets are different.

The water balance was estimated based on the hydrological data. These data allowed us to calculate the evapotranspiration from all the mesocosms.

The chemical and physical data were used to investigate the water quality alternations between different climate scenarios. The mass balance of chemicals was calculated using hydrological and chemical data for all the systems.

The flux of carbon dioxide from the peatland (natural wetland) was measured and analysed to assess whether the peatlands can maintain their positive role of cooling the atmosphere in mitigating future climate change. Moreover, the lakes were monitored in terms of chemical and physical parameters to investigate how they would respond to climate change and how the water quality could vary between the lakes, which receive constructed wetland outflow and those which receive peatland outflow. Additionally, algae growth was analysed to assess the eutrophication problems for the lake mesocosms.

In order to investigate how an engineering solution can help to manage a wetland system, water level management was examined in all systems in the second year of the project and onwards (the current year, which is the third year). This will help to propose a management approach to maintain the important services of the wetland in future addressing climate change.

The statistical method mixed-effect model was applied to analyse for significant differences and to investigate how different factors might significantly affect the systems. The project was looked

at from multiple perspectives by including different aspects of change in various ecosystems as mentioned above.

OsloMet

The aim of the research is to develop a decision support tool for nature-based solutions (NBS). The tool should support the user on multiple stages of the project - from initial planning to the operational phase. The core of the tool will be a decision support module based on machine learning models.

The beginning of the research was focused on an extensive literature and tool reviews. The review focused on screening hundreds of journal papers, dozens of books and web-based tools. Tools were searched using Elsevier, Scopus, ScienceDirect, ResearchGate and Google Scholar. The search encompassed the following keywords: Nature-based Solutions, NBS, Nature Inspired Solutions, Green infrastructure, Climate change, Climate change mitigation, Resilient cities, Sustainable development and Sustainable cities. The review also included the following database-type tools: Horizon 2020 Environment and resources data hub, Climate ADAPT, Water Action Hub, Global Environment Facility, EU Smart Cities Information System and UN Environment Programme World Conservation Monitoring Centre. These tools provide access to databases containing EU and worldwide projects and actions connected to NBS. Among them, the review focused on and summarized the most relevant tools taking into account their deliverables.

The 102 most promising tools (excluding journal papers) were selected for more detailed inspection. In the review, the tools were split into two distinct categories: textbooks and web-based tools. Among those, the tools were categorized into framework, review, case study (textbooks tools) and software, interactive map, database, knowledge platform, framework and case studies (web-based tools). Usually, categories were mixed. As a result of the performed review, a scientific publication titled “The review of 102 design tools for Nature Based Solutions applications” was prepared and submitted to the International Journal of Hydrology Science and Technology.

The second step was to prepare the concept of the RainSolutions decision support tool. The concept draft depicts that a good solution for the decision support tool is a full-stack web-based software. The front end application will be designed as an interactive wizard, which guides a user on the NBS project development process. The tool will be working as follows: firstly, the user will be creating a new project, the tool will guide him through the next steps gathering information on user demands and site measurement data. The user data will be passed through an API to a database storing necessary information. When the tool obtains sufficient information regarding the user site of interest, the models at the back-end will be updated. The machine learning models are initially trained on the case studies stored in the database. The goal is for the

prediction and classification algorithms to calculate optimal recommendations for NBS types in a user-specific case.

The work on the RainSolutions software was started on the back-end (machine learning models), which will be plugged into the website. The research started with implementation of a predictive toolbox. The toolbox contains five modules for data processing and prediction: data import, cleaning, statistics calculation, ML fitting and neural fitting. The tool provides five most commonly used ML techniques are Linear Regression, Regression Trees, Support Vector Machines, Gaussian Process Regression, Ensembles of Trees. Moreover, neural fitting module offer data fitting using a two-layer feed-forward network with sigmoid hidden neurons and linear output neurons. The performance of the toolbox was successfully verified on data provided by ULUND. The toolbox can train models with an average of $R2 > 0.8$. This performance can be treated as very satisfactory when compared to models presented in high quality scientific journals (CAI, Jianchao et al. Prediction and analysis of net ecosystem carbon exchange based on gradient boosting regression and random forest. Applied Energy, 2020, 262: 114566.) Currently, the toolbox is implemented in the Matlab environment, but it will be rewritten to Python. The justification is that Python has ready-made frameworks for web applications and offers similar (if not the same) possibilities to implement machine learning models. Python will be used for both back-end and front-end RainSolutions application implementations.

Currently, OsloMet is focusing on preparing specifications for the RainSolutions front-end. It was decided that the application should have an open form, which enables its further development and adding new functionalities. It is also planned that applications will be shared between OsloMet and other partners. In that way, students will be able to conduct their bachelor and masters projects. It is expected that this would be the best way to obtain sustainable operation and maintenance of the application.

Federal University of Technology – Paraná, Brazil

In the case study of Londrina, PR, Brazil, there are evident delays, which compromised the advances in the original schedule, but not for the original objectives. There are two well-known reasons for this delay. The first one was the delay in the release of funds, which happened on 17 October 2019. The second problem is related to COVID-19, which caused the closure of Brazilian universities from the middle of March 2020. The students selected to work on the project will only be able to attend the laboratories as of November 2020. During the last months, there was also limited access to public areas, in particular to Lake Igapó, whose access is essential for obtaining data. This did not prevent the academic part (online training of students) as well as the methodology from being developed during the pandemic. Although there was a delay in the

original schedule. However, there is no reason to compromise on the objectives. Nevertheless, it will not be possible to deliver results on time.

University of Tartu

Continuous and biweekly water and greenhouse gas measurements at the Estonian case-study, Vända treatment wetlands, have been accomplished. Preliminary data analyses have been conducted and researchers have started preparing the manuscript that will be submitted to The Science of The Total Environment at latest in January 2021. All of the collected data have been quality-checked and also uploaded to the University of Tartu cloud service and access has been granted to Jakub Roemer from OsloMet, who will use the data for modelling activities.

In addition to fieldwork, UT is working with the data that were used to prepare the report: "*D1. Report summarising the state-of-the-art and gaps in knowledge regarding case studies, nations and international scene".* The general aim is to publish a paper about various NBS and their water retention capacity around the world (Figure 1). Most of the analyses have been conducted and a manuscript is under preparation. The paper will be submitted to the MDPI Sustainability Special Issue (editors: Dr Kasak, Prof. Scholz, Prof. Mander).

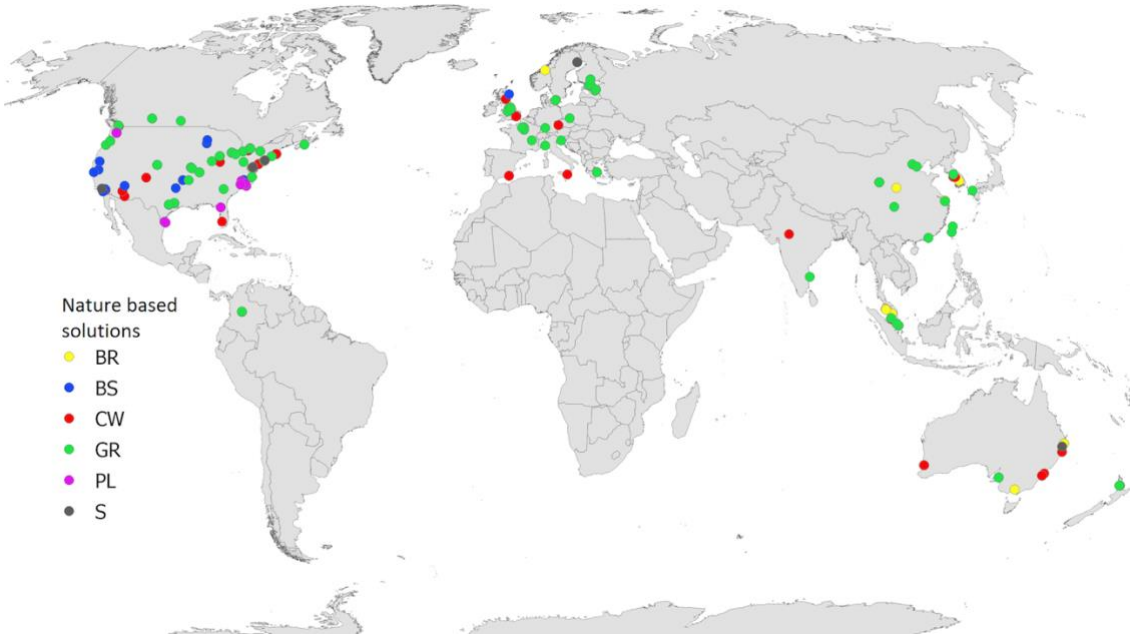

Figure 1. Most widely used studies on nature based solutions for water retention: BR – bioretention, BS – buffer strips, CW – constructed wetlands, GR – green roofs, PL – permeable layer and S – swales.

TYPSA

The proposed construction by the Catalan Water Agency is at the moment only in its planning stage, so TYPSA believes that they will not be able to use it as a case study. Therefore, TYPSA is looking for alternatives.

At the moment, we are looking for a collaboration with the Viladecans Town Hall, which is carrying out a sustainable drainage project based on porous concrete paving instead of traditional drainage in a 200-metre stretch in a street in their city and we are also in talks with the Cosmocaixa Museum in Barcelona to put sensors in place for another sustainable drainage project, which will have a green roof that will collect water from a pergola that is currently made of glass. We are looking at the possibility of collecting water from this roof, storing it in tanks and using it again for irrigation applying solar or wind energy. In this case, we are helping the architects in charge of the construction project. TYPSA is late with the project execution and the new mobility restrictions that are expected to take place in the next few days may make this situation even worse.

WUR

Work package 3 aims to understand the mechanisms of urban pluvial flooding in relation to multiple background factors including urban morphology and climate conditions. To fulfil this purpose, WUR first built an urban storm water model to simulate rainfall associated run-off and transport by a drainage system. The objective of this model is to simulate the response of an urban area to a rainfall event to understand the interactions of the urban components with the associated rainfall run-off. So far WUR has finished the prototype of the model, which integrates QGIS and SWMM. Both software packages are with open access, which will promote the dissemination of our research output.

WUR is currently applying this model to Revierenbuurt, a neighborhood in Amsterdam that has problems related to pluvial flooding and consequential degraded surface water quality. The outcome will be the hydrograph of specific locations, which reveals the probability of pluvial flooding and the required NBS capacity for mitigating this. Researchers are also debugging and improving this model through application. In spring 2020, they have built this model prototype and fulfil their deliverable 3. WUR expects that by summer 2021 they will be able to finalize the model and its application for the Amsterdam case study. The methodology used in this model contains extensive details, so we have documented it in a separate file that is available upon request.

The model construction process has involved different disciplines including environmental technology, geo-information science, landscape architecture design and civil engineering. The application of the model, once it is completed, will further involve other disciplines including urban planning and environmental policy science.

VESI International

A detailed photogrammetry survey of Kilbogget Park, County Dublin, Ireland (GPS: 53.262936, -6.144879) was carried out in May 2020. The purpose of this was to capture aerial imagery and specific surveying details from an existing Integrated Constructed Wetland (ICW) in Ireland, which is situated in a heavily urbanised area. This survey will be mirrored in the Tolka Valley Park, County Dublin (GPS: 53.376385, -6.301888), where a similar approach will be used for surveying the site and used as a tool for community engagement, awareness and education.

The survey has been shown to members of Dun Laoghaire/Rathdown Council of Dublin and with Dublin City Council, who are responsible for Kilbogget and Tolka, respectively. This provides them with an interactive and digital map of one of their most heavily used public amenities in a manner which was not previously available. Collaboration with relevant councils and state authorities has led to the agreement and establishment of a sample programme for the Tolka Valley Park ICW. This should have started in the early autumn. However, due to several challenges with the site and a lack of maintenance having been carried out for several months, leading to blocked inlet pipes, sampling is only now due to commence at the start of November 2020.

Several Dublin City Council staff have been able to coordinate a communication effort with residents in the area of Kilbogget through the local schools, which will allow for public engagement and feedback while ensuring that both COVID-19 restrictions and suitable numbers of outreach are achieved. This has not yet been implemented but is in the stage of planning.

INCDDD

The research project focused on the perception of the authorities and local communities on the aspects related to NBS implemented in Romania, especially in connection with the rehabilitation or reconstruction of urban lakes. At the beginning of the project, an extensive review of the reconstruction projects implemented in Romania was performed. The search included the distribution of questionnaires to local authorities in cities where the existence of watercourses or urban lakes have been identified.

The next step included the selection of three case studies and distribution of questionnaires to local communities with the purpose to assess the significance and importance of urban lakes as well as the perception of changes in water quality and biodiversity after implementing ecological reconstruction projects and how local communities collaborate with local authorities. During the second year of implementation of the project, the RainSolutions team focused on the identification of the appropriate indicators for evaluation of ecosystem services of the key NBS implementation.

INCDDD is currently performing the analyses of data gathered during/from the survey in local communities and preparing a manuscript for the special issue of MDPI Sustainability (editors: Dr Kasak, Prof. Scholz, Prof. Mander).

University of Pretoria

Linear statistical models have been developed for both dam levels and for downstream flows of the Vaal Dam in South Africa. First, concurrent seasonal rainfall data were used for simulating dam levels and downstream flows - for example, December to February (DJF) rainfall totals over the Vaal Dam catchment were used to simulate DJF levels and flows. The reason for testing concurrent seasons is to determine to which extent rainfall in the catchment directly affects levels and flows. Canonical modes of the rainfall were used in a multiple linear regression model as predictors. The models were tested in a 5-year-out cross-validation design. Second, antecedent seasonal rainfall was also used in the same modelling configuration, but for this part of the modelling, prediction skill instead of simulation skill was estimated. For example, September to November (SON) rainfall totals were used to predict DJF levels and flows. Thirdly, for those seasons for which the most skillful simulations and predictions were obtained, SST fields and GFDL (a fully coupled model from the North American Multi-Model Ensemble) rainfall fields were also used as predictors. For SST, for example, the SON temperatures were used to predict DJF levels and flows. For GFDL, DJF rainfall forecasts initialized in November were used to predict DJF levels and flows. Therefore, as with antecedent rainfall as predictor, using SST and GFDL forecasts as predictors, a 1-month forecast lead-time was tested. Finally, simple linear regression was used to see if dam levels can be link to downstream flows.

One of the main objectives is to develop prototype models in order to demonstrate that a subset of the hydrological characteristics of the Vaal Dam is predictable on a seasonal time scale. From verifying the statistical models over a recent 21-year period, the following main conclusions may be drawn:

1. As may be expected, there is a strong link between rainfall in the catchment and dam levels; as well as what happens downstream of the dam. This link is less pronounced during winter.
2. There is also a concurrent link between dam levels and downstream flows, but this link is strongest during the second half of summer and autumn.
3. Real-time prediction for both dam levels and downstream flows is possible, but the predictability demonstrated here is mainly a result of using antecedent rainfall in the catchment as predictor in a statistical model, as opposed to using a climate model's forecasts or SSTs as predictors. This result does not mean that climate model output has been found to be redundant, but rather that one should be considering a range of possible predictors that may or may not include climate model forecasts.

We have provided evidence of predictability that has the potential to be of benefit to managers of the Vaal Dam. Next, we will engage with Rand Water representatives in order to discuss the way ahead for more advanced modelling through a process called co-production, in which forecast users are part of the forecast system development.

b) Collaboration, coordination and mobility

Federal University of Technology – Paraná, Brazil

The exchange of information and collaboration by the Brazilian participants has been effective. Although there have been mobility challenges related to the case study (Igapó lake, Londrina, PR), and activities to be carried out by masters students. With the pandemic, mobility has been limited. The case study is associated with a large national project entitled "The role of climate and land use changes on the hydrological regime of the Parana River Basin, Brazil" (Grant number: 23038.003963/2016-17, Edital Capes/ANA nº 19/2015). In this collaboration, the consortium will benefit from computational infrastructure as well as rain, streamflow and water quality data for the chosen case study.

Lund University

Good collaboration between ULUND and OsloMet has been established. The data ULUND has generated over years are being used for machine learning by OsloMet.

OsloMet

Collaborations with ULUND and TU were established. TU provides a big database on their case study (constructed wetland) with descriptions and a scientific database related to their case study (constructed wetland) with descriptions and related scientific articles (references). The collaboration between OsloMet and ULUND continuous with digital (Skype) meetings once per 1-2 weeks. The common research is focused on verifying effectiveness of machine learning techniques for modelling wetland mesocosms. The work was conducted in an iterative manner on multiple datasets provided by ULUND. The final goal was achieved in October 2020, when robust and high precision (R2>0.8) prediction models were developed. One of the collaboration outcomes will be a common scientific publication, which is currently under development.

WUR

The Amsterdam Institute of Advanced Metropolitan Solutions (AMS-institute) and Amsterdam Rainproof (part of Waternet) have expressed their intent to provide in-kind support. Their support includes provision of practical data, the provision of practical knowledge, the connection to relevant stakeholders as well as the participation and co-organization of dissemination activities. In this first phase of the project (2019.07 – 2020.08), Waternet has provided data for building our model prototype and co-organized one knowledge exchange meeting. The AMS institute has also co-organised one knowledge exchange event and they will further contribute to data collection and stakeholder facilitation in the project.

INCDDD

INCDDD had a good exchange of information and collaboration for the D1 report, and the collaboration continued for the D2 report. Collaborations with consortium partners includes support, the collection of data on local communities and local authorities, as well as participation in dissemination activities.

c) Impact and knowledge output

OsloMet

Several impacts were recorded within this on-going project. The first one regards promoting knowledge on NBS and its potential to water management in cities and rural areas. The review of 102 NBS tools was performed and submitted to an international scientific journal. The article was written to aim both at inexperienced readers and veterans in the NBS topics. It will help to promote the concept of NBS through a wide audience.

The RainSolutions project has also contributed to the Digital VEAS hackathon 2020. The goal of the hackathon was to locate bottlenecks caused by heavy rain and reduce spilling of untreated water to the Oslo Fjord. Two project participants (Tiina Komulainen and Jakub Roemer) as organizers of the hackathon promoted the idea of the RainSolutions project. As the result of this cooperation, one student master thesis proposal was announced. In the academic year 2020/2021, a group of students will face the challenge of using NBS for flood mitigation in the Oslo area. In their work, they will be using and participating in developing RainSolutions decision support software.

Currently there are discussions to collaborate with the VEAS wastewater company for further initiatives. A feasibility study is planned to identify the potential for using the RainSolutions project outcomes for storm water management and flood mitigation.

Federal University of Technology – Paraná, Brazil

Due to the delay in releasing funds and the restrictions caused by the pandemic, no expected impact for the Igapó lake case study (Londrina, PR, Brazil) can be reported. Expected beneficiaries of the project are end-users of the lake area (commerce, leisure and sports) and policy makers engaged with the management of public areas and the environment.

WUR

Work package 3 generated impact mainly on knowledge creation and business and investment cases. RainSolutions has created modelling tools to support optimal planning of NBS and assess the benefits of various small-scale NBS at a higher scale. The tool will support and strengthen future scientific research into NBS and also help promote the optimal use of NBS in practice.

Table of Deliverables

Deliverable name	Lead partner (country)	Date of delivery (dd/mm/yyyy)	Changes, difficulties encountered and new solutions adopted
WP1			
D1. Report summarising the state-of-the-art and gaps in knowledge regarding case studies, nations and international scene.	UT	31/08/2019	
WP2			
D2. Report on environmental improvements evidenced by indices through NBS benefitting case studies and partner countries.	DDNI	*31/05 /2020*	None. A report on the D2 is available upon request. During the model application, researchers found out that the geographical resolution in GIS and SWMM are not always compatible. Work on solving this challenge is on-going.
WP3			
D3. Report and a prototype of geo-spatial model (to be delivered to WP5) on urban resilience benefitting case studies and partner countries.	WUR	30/04/2020	
WP4			
D4. Report on NBS benefitting social inclusion, particularly in case studies located in	OsloMet	30/04/2020	A first draft of the report has been completed. However, it can be improved during the

deprived areas and partner countries.			project once more information becomes available.
WP5			
D5. Framework provision based on input from WP1 to 4.	OsloMet	30/02/2021	The initial data of a case study (provided by Lund University) have been used to develop modelling techniques to help the design of the framework. The differences in cases studies led to the challenge of selection of coherent cases to help progress. The front- and back-end designs of framework are ongoing.
WP 6			
D6. Report on case study applications of the framework and recommendations for improvements to be undertaken in WP5 (iterative consultation process between WP).	VESI	30/11/2021	
WP7			
D7. Communication and public engagement strategy plan delivery.	ULUND	30/06/2019	
D8. Initial public engagement consultations case study areas.	ULUND	31/01/2020	
D9. Final public engagement consultations case study areas.	ULUND	30/07/2021	
D10. Journal review paper summarising the state-of-the-art and gaps in knowledge.	ULUND	31/10/2020	Work in progress by various partners
D11. Journal paper(s) on outcomes of W2 to W4.	ULUND	30/06/2020	Work in progress by various partners

D12. Framework (open access) and journal paper(s) on framework.	ULUND	30/04/2021	
D13. Journal paper(s) on framework applications.	ULUND	31/01/2022	

Budget review

Coordinator (Lund University)

Period Start: 2020-01
Period End: 2020-10
Mina/Alla projektgrupper: Alla projektgrupper
Fakultet: LTH
Institution: Bygg- och miljöteknologi
Aktivitetsstatus: Aktiva aktiviteter
Aktivitet: 135384 - Scholz - FORMAS JPI

Financial report (project)	**Outcome** from project start	**Outcome** selected period
Income		
Grants	2 411 497	1 033 497
Other external income	1 233	773
Income Total	**2 412 730**	**1 034 270**
Expenses		
Salaries	-1 016 046	-763 254
Costs for vacation	33 080	20 853
Subsistence allowences	-20 434	-4 774
Travel expenses	-74 500	-31 489
Sub-contracting	-139 561	-78 360
Consumables, running costs	-248 856	-139 152
Premises	-171 267	-120 388
Indirect costs, overheads	-503 303	-360 303
Expenses Total	**-2 140 887**	**-1 476 869**
Total	**271 843**	**-442 599**

Other transactions	0
Available funds (yesterday´s balance)	**271 843**
Preliminary overheads/allocated indirect costs	-31 577
Preliminary cash balance (yesterday´s balance)	**240 266**

SEK 1 = EUR 0.09595 (29 October 2020) (ECB euro reference exchange rate: Swedish krona (SEK))

Partner 1 (University of Johannesburg)

Year	Income	Expense for travel	Expense for Materials	Personal cost
2019	0	2 976 €	0	0
2020	9200 €	0	0	2000 €

Partner 2 (University of Pretoria)

Two deliverables were completed, each worth **ZAR90,000**. These are:
1. Knowledge Gap (Why we need to develop hydro-climate forecast models)
2. Prototype (Preliminary prediction models to test predictability of dam inflows and levels)

ZAR90,000 = 4,680.00 EUR

ZAR 1 = EUR 0.05200 (29 October 2020) (ECB euro reference exchange rate: South African rand (ZAR))

Partner 3 (VESI Environmental Ltd.)

Year	Staff	Equipment	Overheads	Sampling	Total
2019	9988.29	8000	5336.49	0	23324.78
2020	17159.6	0	5147.88	7800	30107.48
2021	12312.29	0	3693.69	0	16005.98
2022	0	0	500	0	500

Partner 4 (Federal University of Technology, Londrina, Brazil)

Date	Debit (Real)	Credit (Real)	Balance (Real)	Balance (Euro)	Currency (Euro/Real)
October-2019		89400.00	89400.00	20089.89	4.45
November-2019			89400.00	19143.47	4.67
December-2019		583.94	89983.94	19907.95	4.52
January-2020			89983.94	19477.04	4.62
February-2020			89983.94	18215.37	4.94
March-2020		33000.00	122983.94	21652.10	5.68
April-2020	10200.00	102000.00	214783.94	36465.86	5.89
May-2020	6000.00		208783.94	34624.20	6.03
June-2020	6000.00		202783.94	33188.86	6.11
July-2020	6000.00		196783.94	31997.39	6.15
August-2020	6000.00		190783.94	29171.86	6.54
September-2020	6000.00	1652.06	186436.00	28120.06	6.63
October-2020	6000.00		180436.00	27051.87	6.67
Total	46200.00	226636.00	180436.00	27051.87	6.67

Partner 5 (Técnica y Proyectos S.A.)

Note that this partner contributes to the project with its own financial resources.

Year	Cost for personnel	Cost for travel	Cost for materials
2019	1260,00 €	0	0
2020 (31-OCT)	1440,00 €	0	0
2021	0	0	0
2022	0	0	0
Total	**2700,00 €**	**0**	**0**

Partner 6 (Oslo Metropolitan University)

EUR	2019	2020
External funding received		-118,974
Payroll and indirect expenses	16,134	69,357
Purchase of R&D		
Other goods and services	2,290	1,682
Balance 30.09.2020		**-29,511**

Year	Personnel costs	Other costs	Subcontracting	Equipment
2019	16,134	2,290		
2020	110,508	19,419	10,680	9,709
2021	141,661	14,564		4,855
2022	33,012	5,826		
Total	**301,315**	**42,099**	**10,680**	**14,564**

EUR	Credit	Debit	Balance
Sep-19	0	463	463
Oct-19	0	14,222	14,686
Nov-19	0	1,791	16,477
Dec-19	0	1,947	18,424
Jan-20	0	0	18,424
Feb-20	-18,836	0	-413
Mar-20	-50,069	999	-49,483
Apr-20	0	7,273	-42,210
May-20	0	1,816	-40,395
Jun-20	-50,069	0	-90,463
Jul-20	0	29,454	-61,009
Aug-20	0	22,545	-38,464
Sep-20	0	8,953	-29,511
Total	**-118,974**	**89,462**	**-29,511**

Partner 7 (Wageningen University and Research)

Year	Cost for personnel	Cost for travel	Cost for material
2019	33000	2000	0
2020	77000	3000	3500
2021	77000	3000	3000
2022	46755	1905	0
Total	233755	9905	6500

Partner 8 (University of Tartu)

Date	Credit(€)	Debit(€)	Balance(€)
August-2019	23352.00		23352.00
September-2019		3894.04	19457.96
October-2019		3215.01	16242.95
November-2019			16242.95
December-2019		1750.79	14492.16
January-2020		1110.54	13381.62
February-2020		1334.78	12046.84
March-2020		1418.73	10628.11
April-2020			10628.11
May-2020			10628.11
June-2020			10628.11
July-2020			10628.11
August-2020	6648.00		17276.11
September-2020			17276.11
October-2020			17276.11
Total	30000.00	12723.89	17276.11

Partner 9 (Danube Delta National Institute for R&D)

ANUL Year	Sursa 1 (euro) UEFISCDI	Sursa 2 Cofinantare (euro)	Sursa 3 - CE (euro)[6]	TOTAL (euro)
2019	40.000,00	0,00	6.137,00	46.137,00
2020	50.159,00	0,00	24.856,00	75.015,00
2021	16.629,00	0,00	6.395,00	23.024,00
2022	5.163,00	0,00	6.599,00	11.762,00
TOTAL	111.951,00	0,00	43.987,00	155.938,00

Consortium Meetings

N°	Date	Location	Attending partners	Purpose/ main issues/main decisions?
1	24-26 Sep. 2019	Oslo, Norway	All but partners 2 and 5 remotely	Partners introduction, case-studies and framework planning
2	17-19 Feb. 2020	Tartu, Estonia	All but Partners 1, 2 and 5 remotely	Synergy in selection of case-studies for framework validation
3	Planned 19 Nov. 2020 (virtual)	Johannesburg, South Africa, Virtual meeting	All partners remotely	
4	Planned	Brazil		

Stakeholder/Industry Engagement

Advisory Board

An advisory board team led by OsloMet has been established.

Terms of Reference for the Advisory Board:
The Advisory Board is comprised by authority representatives and scientific experts to overview the activities of the project and will act as a constant review panel expressing its opinions on decisions, reports and any issues on demand by the project coordinator. The advisory board will formally meet at least once per annum over the course of the project as well as being invited to meetings, when and where appropriate.

Advisory Board is:

- To receive summaries of the project main reports and advise on relevance and future planning
- To identify opportunities in industrial and commercial collaboration
- To develop opportunities in commercialisations and use of the project outcomes
- To exchange ideas and views with external bodies that have mutual interests within the project objectives
- To advise on changes and advances within the project subject area to align with governmental, commercial and industrial needs.

Advisory Board Members:

Internal Members:

- Huub Rijnaarts (HR) Wageningen University, The Netherlands
- Liliana Török (LT) Danube Delta National Institute, Romania
- Linus Zhang (LZ) Lund University, Sweden
- Miklas Scholz (MS) Lund University, Sweden
- Mojtaba Moatamedi (MM) Oslo Metropolitan University, Norway
- Ronny Berndtsson (RB) Lund University, Sweden

External Members:

- Bjørn Kløve (BK) Oulu University, Finland
- Christopher pain (CP) Imperial College London, UK
- Daniel Goedbloed (DG) Amsterdam Rainproof, The Netherlands
- Frans van de Ven (FV) Delft University of Technology, The Netherlands
- Pere Malgrat (PM) City Council of Barcelona, Spain
- Rasheed Aleem (RA) Sharjah Electricity and Water Authority, UAE
- Thurai Rahulan (TR) University of Salford, UK
- Yali Woyessa (YW) Central University of Technology, South Africa
- Zoran Kapelan (ZK) Delft University of Technology, The Netherlands
- Doina Cioaca Ministry of Environment, Romania
- Nan Su Dutch Sino Business , The Netherlands

The first Advisory Board meeting was held on Friday, 7 February 2020 (via Skype). A further physical meeting was planned to take place in Oslo this year. However, the meeting had to be cancelled due to recent world development concerning the COVID-19 pandemic. Therefore, the second meeting is planned for 2021.

OsloMet

The VEAS wastewater company for Oslo, Asker and Bærum municipalities was involved in the project. The cooperation was established by organizing Digital VEAS hackathon 2020. The aim of the hackathon was to engage groups of students in modelling and simulation of an urban drainage network. The challenge was to locate bottlenecks caused by heavy rain and reduce wastewater spillage to the Oslo Fjord. The digital Hackathon started on 15 October 2020 and took 24 h. The winning team identified the risk area for Oslo, which potentially has the biggest influence for storm channel overflow.

The follow-up of the hackathon activity will be an attempt to utilize the RainSolutions decision support tool. The tool will be used to model the potential outcome of using NBS solutions in the Oslo area for flood mitigation. VEAS gave NOK 10,000 as an award to the winning team.

Federal University of Technology – Paraná, Brazil

In the case study of Londrina, PR, Brazil, the National Water Agency was successfully involved, which provided all hydro-climatic data for the lake Igapó, in addition to 10 rain gauges and the guidelines/training for Water Quality Index measurements. Regarding the progress made so far in this case study, the following stands out: the selection of professionals with an adequate profile for each work area (hydrology, modelling, land use and NBS), the training of these professionals during the pandemic period through online courses, the definition of the hydrological model and the organization of the database that will be used to obtain the deliverables of the case study.

University of Tartu

Successful cooperation took place with local project companies (e.g., Alkranel LCC) that are designing treatment wetlands. The knowledge and recommendations based on our results for more suitable design parameters are distributed. The recommendation will focus on three major issues: water treatment efficiency, greenhouse gas emissions and biodiversity. The general aim is to design systems with maximum nutrient removal efficiency while lowering the greenhouse gas emissions and providing suitable habitat for amphibians.

WUR

At work package level, WUR has succeeded in engaging public and industrial partners. For example, as the WP3 leader, WUR is involved in the industrial partner engagement within The Netherlands. Together with OsloMet, WUR will further upscale work in The Netherlands to a European and international level. WUR has acquired several valuable data sets from their partner Waternet. This includes the surface water monitoring data from 1970 until 2020 as well as the GIS maps of land use and sewer systems in Amsterdam. Based on this, WUR will develop their model based on the characteristics of the available data and test and validate the model application based on this and future data. The model development has drawn attention from other Dutch municipalities like Breda and Nieuwegein; both of them are going to provide similar data and invite WUR to advise on future monitoring schemes for the effectiveness of NBS.

Within the consortium, WUR has also a strong industrial partner (VESI) that is able and willing to provide several monitoring data from wetlands they have built to support the model development in WP3 and the design of NBS in several case studies. At the project level, we have managed to engage several other internationally leading business partners in the field of integrated water management and NBS into our supervisory board. This includes Nan Su (co-funder of the Dutch-Sino Business Promotion company active in the business field of sustainable food and water systems).

WUR is working on engaging business partners in the field of landscape architecture and spatial planning. They will be one of the target end-users of the knowledge that has been generated. The university will engage them to the model application in WP3 and WP5 as well as the design exercise in the planned case studies.

An unexpected impact is the high interest in this knowledge from several municipalities and even provincial governments in the outcomes including tools generated by RainSolutions. So far in WP3, there are more municipalities engaging, both in Europe and outside of Europe (e.g., Suzhou and Xiamen in China).

List of Publications produced by the Project - Open Access

International	Peer-reviewed journals	1. J. Roemer, T. Komulainen, M. Moatamedi, M. Scholz. The review of 102 design tools for Nature Based Solutions applications. International Journal of Hydrology Science and Technology. 2020. (SUBMITTED) 2. J. Roemer, T. Komulainen, M. Moatamedi. RainSolutions – the concept of decision support tool for Nature Based Solutions projects. Sustainability. 2021. (UNDER PREPARATION) 3. J. Roemer, W. Kisielewska, T. Komulainen, M. Moatamedi. The review of Machine Learning based modeling strategies for Nature Based Solutions design. (UNDER PREPARATION) 4. J. Roemer, S. Salimi, W. Kisielewska, M. Scholz, M. Moatamedi. Prediction of peatland carbon dioxide exchange based on climate chambers experiments. Applied Energy. 2021. (UNDER PREPARATION)
	Books or chapters in books	
	Communications (presentations, posters)	
National (separate lists for each nationality)	Peer-reviewed journals	
	Books or chapters in books	
	Communications (presentations, posters)	**INCDDD** 1. Scholz M., Török L., 2019, Research-based Assessment of Integrated approaches to Nature-based Solutions (RainSolutions). IN: Deltas & Wetlands (Book of abstracts), vol 6, 30 pp, Tulcea, Romania. 2. Scholz M., Török L., Research-based Assessment of Integrated approaches to Nature-based Solutions (RainSolutions), poster, The 27th Symposium 'Deltas and Wetlands', 05 - 09 June 2019, Tulcea, Romania. 3.
Dissemina-tion initiatives	Popular articles	
	Popular conferences	
	Others (cooperation protocols for project dissemination & promotion, newspapers,	**INCDDD** 1. Dansul Moleculelor de Apă, News, Delta newspaper, October 9, 2019, Romania 2. Three collaboration protocols with high schools from Romania

	newsletter, webpages etc.)	3. Web pages: http://ddni.ro/wps/ro/project/rainsolutions_ro/ https://www.researchgate.net/project/Research-based-Assessment-of-Integrated-approaches-to-Nature-based-SOLUTIONS-RainSolutions https://twitter.com/torok_zsolt2004/status/1191687250251276288) https://www.linkedin.com/feed/update/urn:li:activity:6597453393873117185/ https://www.facebook.com/zsolt.torok.378/posts/2609221499134698 **University of Tatu** A Special Issue has been launched at the MDPI Sustainability journal (IF: 2.576) "Nature-based solutions to reduce the flood risk in cities and peri-urban areas". Editors: Dr. Kasak, Prof. Scholz, Prof. Mander

Knowledge output transfer

Short Title *Please provide a short and concise title to describe the Knowledge Output*	
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated.* *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.* *If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).*	
Knowledge Type	**INCDDD** Report 2019, Construind în baza a ceea ce cunoaştem, 78 pag.. Raport Etapa 1 / decembrie/ 2019, proiect

	RainSolutions (coord. Liliana TÖRÖK), contract nr. 108/ 2019 / UEFISCDI, executant: INCDDD Tulcea, România **OsloMet** Software/toolbox: Within WP5, the toolbox for constructed wetland carbon dioxide prediction was developed. Currently, the software is implemented in Matlab. It will be rewritten to Python and disseminated within the GitHub platform. A report on using software on ULUND data is available.
Link to Knowledge Output *If you can provide a link to the Knowledge Output then please do so, e.g. digital object identifier (DOI), web address, download, research paper.* *If the Knowledge Output is not publicly available currently but will be in the future, please provide details. Also, if it is available but only upon request, please state this.* *If the Knowledge Output is not planned to be publicly available, please state "Not available for public".*	
Sectors & Subsectors *Choose as many options as required from the list. Pick those sectors that you think would benefit from the application of this Knowledge Output.*	
End User *Choose as many options as required* *Per identified End User, please identify possible applications of the Knowledge Output.*	
IPR *Please indicate whether IPR has been applied to this Knowledge Output (applied for a patent, copyright etc), or not.* *Please insert "n/a" if no IPR has been applied.*	n/a
Policy-Relevance	The promotion of NBS can has positive impact on fulfilling the WFD directive in increasing

If the Knowledge Output is relevant to the WFD or any other related Directives, please list and explain why	'biological quality', 'hydromorphological quality' and 'physical-chemical quality' of all ground and surface waters.
Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?* *• Does your knowledge progress beyond the current state-of-the-art / evidence base?* *• Is more research or demonstration needed to validate the results?*	Currently the Knowledge Output is still being generated.

Open Data

Federal University of Technology – Paraná, Brazil

Open data sets for the case study of Londrina, PR, Brazil are expected to be delivered only after the second semester of 2021.

VESI International

The generation of data and resources from the studies in Ireland will provide knowledge for open sharing. However, any publication in which VESI and the Irish EPA are directly associated with must receive full authorisation and approval from the EPA, as laid out by the terms and conditions of the funding agencies.

Problems Encountered during Project Implementation

Federal University of Technology – Paraná, Brazil

The beginning of the project coincided with the change of government, as well as staff of the project's national partner. This ended up delaying the process of verifying documents and legal requirements with subsequent delivery of funds.

University of Johannesburg

There was a delayed in the process of contract agreement and signature. This problem has delayed the budget release. Moreover, the long lockdown in South Africa due to the COVID-19 pandemic has affected the progress of the project significantly. The delay in budget release and the COVID-19 pandemic affected the project inception, student selection, student registration and data collection. Postgraduate students are unable to do their research. The students are not active for the current academic year (2020). Due to many uncertainties amid COVID-19, UJ requested the funding body (WRC) to extend the due date for some deliverables.

University of Pretoria

Similar to the University of Johannesburg, the long lockdown in South Africa due to the COVID-19 pandemic has also affected the progress of the project. Moreover, the lead investigator suffered from a serious illness for many months until October 2020

Suggestions for improvement regarding project implementation?

There is room for improvement of communication between partners particularly during the pandemic. A proposal for monthly partner summaries to be sent to all partners will be discussed at the next general assembly meeting.