SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D4.17

DEPLOYMENT OF SENSORS AROUND THE AMERSFOORT RAILWAY STATION, INCLUDING SELECTION AND FORMAL PERMIT FOR MONITORING

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ABBREVIATIONS

Abbreviation	Definition
ICT	Information and Communications Technology
IoT	Internet of Things
SDG	Sustainable Development Goals
COA	City of Amersfoort

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PROJECT ABSTRACT

SCOREwater focuses on enhancing the resilience of cities against climate change and urbanization by enabling a water smart society that fulfils SDGs 3, 6, 11, 12 and 13 and secures future ecosystem services. We introduce digital services to improve management of wastewater, stormwater and flooding events. These services are provided by an adaptive digital platform, developed and verified by relevant stakeholders (communities, municipalities, businesses, and civil society) in iterative collaboration with developers, thus tailoring to stakeholders' needs. Existing technical platforms and services (e.g. FIWARE, CKAN) are extended to the water domain by integrating relevant standards, ontologies and vocabularies, and provide an interoperable open-source platform for smart water management. Emerging digital technologies such as IoT, Artificial Intelligence, and Big Data is used to provide accurate real-time predictions and refined information.

We implement three large-scale, cross-cutting innovation demonstrators and enable transfer and upscale by providing harmonized data and services. We initiate a new domain "sewage sociology" mining biomarkers of community-wide lifestyle habits from sewage. We develop new water monitoring techniques and data-adaptive storm water treatment and apply to water resource protection and legal compliance for construction projects. We enhance resilience against flooding by sensing and hydrological modelling coupled to urban water engineering. We will identify best practices for developing and using the digital services, thus addressing water stakeholders beyond the project partners. The project will also develop technologies to increase public engagement in water management.

Moreover, SCOREwater will deliver an innovation ecosystem driven by the financial savings in both maintenance and operation of water systems that are offered using the SCOREwater digital services, providing new business opportunities for water and ICT SMEs.

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EXECUTIVE SUMMARY

As part of SCOREwater, the City of Amersfoort has installed sensors to measure soil moisture, temperature and humidity. A part of the sensors were developed by citizen science collective Measure Your City. The other sensors were purchased by the City of Amersfoort from local suppliers. The data will be used in urban planning processes to gain a more precise insight on the changing environment. All data collected will be published as open data on the SCOREwater platform, to allow interested parties to use the data.

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1. INTRODUCTION COA CASE AND USE OF SENSORS

In the City of Amersfoort (hereafter: COA) case the overall goal is to contribute to the redevelopment of the city, in such a way that it becomes more resilient to climate change. One way to do so is by using sensors to gain insight in current climate change related indicators. This report describes why this adds value to the city, how and where the sensors will be used, how sensors were selected and how the formal permit for deployment and monitoring was obtained.

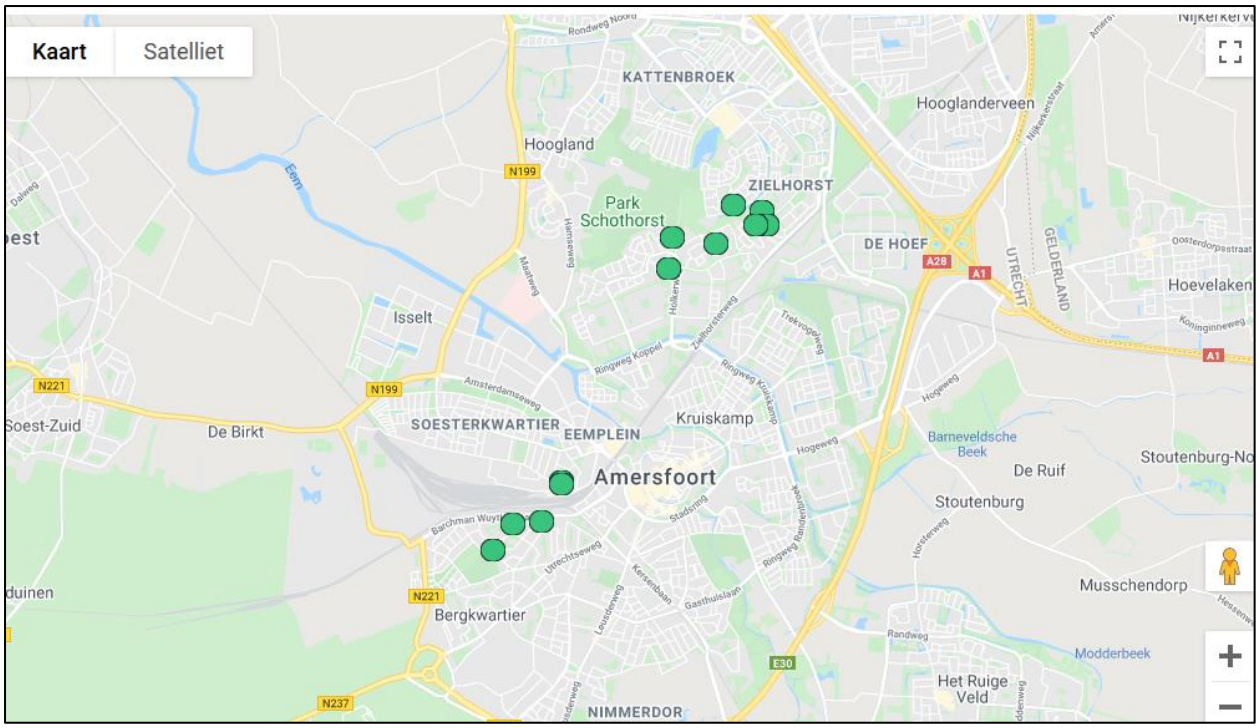
Using sensors to gain data and insight

Firstly, it is important to note why sensors add value to the stated case goals. Sensors provide data that show how certain parameters develop over time. By analyzing the data these sensors provide, insight is gained into which variables effects these parameters. COA currently mostly uses models that give a prediction of values, based on modelled calculations or sensors placed in different areas of the country. By deploying sensors in Amersfoort, we are able to analyze more precisely what is happening, and how we can alter the surroundings in an effective way.

Before elaborating on how sensor data is used, it is important to know what these sensors will measure, how many sensors are in place and where they are located. Figure 1 shows an overview of where the sensors are located. Deployment sites include the Schothorst Area (figure 2, left) and the Central Railway area (figure 3, right). Furthermore, table 1 shows an overview of both existing sensors and sensors that are recently deployed, including their most important characteristics.

In terms of location, areas were chosen for different reasons. The chosen areas (Schothorst and the Central Railway area) largely differ in groundwater levels. In Schothorst the groundwater levels are higher (average height: 0,7m to 1,0m below ground level) than in the Central Railway area (average height: lower than 1,6m below ground level). The lowest soil moisture sensors are placed on 1,2m below ground level. As a result, in the Schothorst area the sensors are located close to or in the groundwater during winter. In the Central Railway area they are located far above the groundwater level.

This makes both areas interesting to include. What all soil moisture sensors have in common is that they are all located nearby trees and in public spaces. Locations differ in terms of: being in the sun or in the shade, being in a green setting (unpaved, such as parks) or being in a paved setting, and being near surface water or not.



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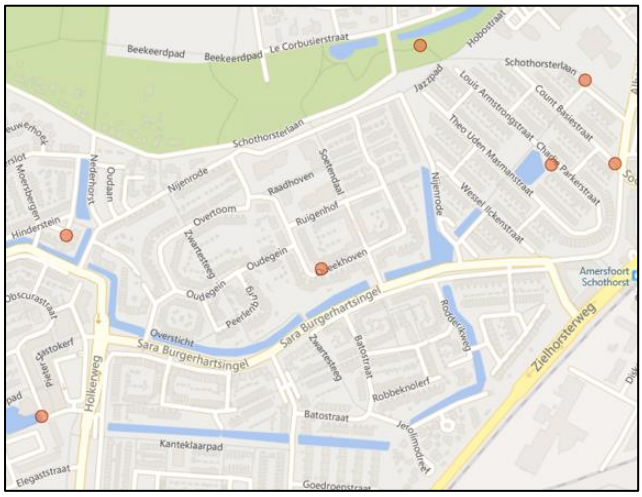

Figures 1, 2 and 3: overview of locations of the recently deployed sensors. At each of the green / orange dots, sensors have been deployed. Figure 2 (on the left image) shows sensors in the Schothorst area, figure 3(on the right image) shows sensors near the Central Railway area.

Table 1: new and existing monitoring points. Listed are all the sensors that are located in the city of Amersfoort and that are integrated on the SCOREwater platform. Column 2 shows which sensors have been installed specifically for SCOREwater (labelled Y for Yes), and which were installed earlier (labelled N for No).

Fixed or flexible location	Installed for SCOREwater Yes (Y) or No (N)	Parameter	Data transmission	Number of sensors in place	Citizen Science (Yes or No)	Owner of the sensor
Fixed	N	Groundwater levels	Manually (using a logger)	200	No	City of Amersfoort
Fixed	Y	Temperature	LoRaWAN	12	No	City of Amersfoort
Fixed	Y	Humidity	LoRaWAN	12	No	City of Amersfoort
Fixed	Y	Soil Moisture	LoRaWAN	36	No	City of Amersfoort
Fixed	Y	Soil Moisture	LoRaWAN	10	Yes	Measure Your City
Fixed	Y	Temperature	LoRaWAN	10	Yes	Measure Your City
Fixed	Y	Humidity	LoRaWAN	10	Yes	Measure Your City
Fixed	N	Temperature	LoRaWAN	60-80	Yes	Measure Your City
Fixed	N	Humidity	LoRaWAN	60-80	Yes	Measure Your City
Fixed	N	Precipitation	Unknown (is being checked)	5	No	ROVA

As the table shows, the newly installed sensors measure soil moisture, temperature and humidity. They include two different owners: the first type are the sensors owned by the City of Amersfoort. These were developed by the company Teneo. Specifications on the soil moisture sensors can be found via https://teneo-iot.nl/brochure-bodemvochtsensor/ (website in Dutch). The second type of sensors are deployed and owned by citizens science collective Measure Your City. More information about this project will be given in the following paragraph.

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Furthermore, data on groundwater levels is also published on the SCOREwater platform. Data on precipitation has not yet been published on the SCOREwater platform: this will happen later in 2021. All data gathered by the sensors will be published as open data on the SCOREwater platform.

Measure Your City

As stated earlier, some of the sensors deployed were developed by citizen science collective Measure Your City. Measure Your City was started in 2015 by inhabitants of the City of Amersfoort, with the goal of measuring climate related indicators. To be able to do so, collaboration was sought with the City of Amersfoort, the local Water Authority and the University of Applied Sciences of Amsterdam. For the first three years the initiative focused on measuring temperature and humidity. Importantly, citizens develop their own research questions, analyze the data together with professionals and discuss potential implications. By doing so, the collective uses citizen science to spread knowledge on both technology and climate change in the most grass-roots manner possible.

Within the SCOREwater project, Measure Your City was asked to expand measurements with soil moisture measurements and additional temperature and humidity sensors. Later in the project we will investigate whether it is possible to measure wind and light intensity as well; together with temperature and humidity measurements this should allow for a modelling of apparent temperature. Apparent temperature as defined by Wikipedia is "the temperature equivalent perceived by humans[1]". By being able to model apparent temperature, an even more precise investigation of heat-stress is possible.

An important note here is that Measure Your City develops their own sensors, has developed their own data platform and uses its own gateways purchased from the Things Network. As a result, much effort is put into constructing sensors that are reliable, low-maintenance and accurate. The latter is important for COA as well, which intends to not only work on shared knowledge and understanding, but also use the data for policy making. To do so the data has to be reliable. By deploying both these sensors and purchasing company-built sensors, we can compare the data to assess how reliable the Measure Your City sensors are. This is part of the next stage of the project, and results will used to further develop the citizen science sensors.

2. MARKET SCREENING

This paragraph describes the purchasing of commercial sensors (e.g. the non-citizen-science-sensors).

Purchasing sensors that both are able to measure the aforementioned variables and are able to connect via LoRaWAN, was new for the City of Amersfoort. To gain insight in the possibilities regarding the purchase of these sensors, a market orientation was used to discuss possibilities with three vendors. The goal of the orientation was to gather information in the products and services that these vendors had to offer. This information was used to see if the needs of the City of Amersfoort could be met.

After the market orientation, one of the vendors was asked to give a detailed offer based upon the requirements prescribed by the City of Amersfoort. Based on these requirements, the vendor (Hoefakker) offered a solution for both the sensors and communication software. As this offer suited the needs of City of Amersfoort, the offer was accepted.

Four important topics that were taken into consideration (both during the market orientation and the conversations with Hoefakker), were:

1. Price

In the Amersfoort case we aim at using low-cost sensors. The entire budget was determined at a maximum of 50.000 euro. However, this also includes costs for installing LoRaWAN gateways that are required for data transmission. As such, the City of Amersfoort has aimed at purchasing sensors that range in price between 100 and 250 euro.

2. Connectivity

[1] https://en.wikipedia.org/wiki/Apparent_temperature

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The Amersfoort case uses LoRaWAN as the Internet of Things standard. To do so, two gateways were purchased and installed. LoRaWAN is preferred because it ensures scalability in the future, and is also used by different sensors (both of the City of Amersfoort and Measure Your City).

3. Lock-in

To prevent vendor lock-in, agreements were made with regards to the sensors used. Firstly, all data is owned by the City of Amersfoort. Furthermore, after the contract expires both the sensors and the gateways are owned by the City of Amersfoort. This ensures flexibility for the future. For example, this ensures that after the contract expires, the city is free to choose whether it uses the sensors in the same location or in different locations, and is free to continue collaboration with the same partners or with different parties.

4. Maintenance

As stated, an important thing to consider was the maintenance of the sensors. For the duration of the project, supplier Hoefakker is responsible for the maintenance of the sensors and the gateways.

3. FORMAL PERMIT AND NGE'S

Before being able to install the sensors, the municipality had to obtain formal permits to do so. Most important issue was that in Amersfoort, there is a high risk of non-exploded explosives still being located in the ground. These are remnants of bombs that were dropped during the Second World War. As such, when digging into the ground with depths of more than 80 centimeter, a protocol has to be followed. An external construction company (Heijmans) was consulted to make sure that the proper procedure was put into place. According to this advice, the people placing the soil moisture sensors had to use a predefined protocol. This protocol describes which actions are necessary to ensure proper installment. The protocol was used during the installment of the sensors. All sensors are placed in public environment, which is owned by COA.

4. INSTALLATION AND COMMUNICATION

Installation of the sensors was planned together with officials of the municipality, representatives of the company supplying the sensors (Hoefakker) and representatives of the citizen science collective. The first sensors were deployed on the 9th of September 2020. The soil moisture sensors were placed in the ground (at depths of 40, 80 and 120 centimeters); the temperature and humidity sensors are placed nearby in lampposts or trees. Stickers with information on the project were placed on the sensors to provide more detailed information about the project to those who are interested in gaining this information.

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Figures 4 and 5: installation of the soil moisture, humidity and temperature sensors used in the SCOREwater project. On the picture we see digging of the hole where the soil moisture sensor is placed (left), and a measuring unit used by Measure Your City (right).

Figure 6 and 7: pictures showing the team who worked on deploying the sensors (left) and alderman Fatma Koşer Kaya, who was one of the speakers at the ceremony surrounding the deployment of the last sensor (right).

To engage citizens and make them aware of the deployment of the sensors, several actions were taken:

- Letters were sent to citizens living nearby measuring sites;
- Together with Future City, a social media post was used to get digital coverage. This was also shared via the municipality's social media;
- Press was contacted, resulting in several articles online being published and shared (AD, Stadszaken, Amersfoort Duurzaam etc.);
- Together with Measure Your City, the development and deployment of the sensors was shared during Measure Your City online meetups, via the Measure Your City newsletter and via the Measure Your City social media.

5. INTEGRATION AND PUBLICATION ON THE SCOREWATER PLATFORM

The data collected in the Amersfoort case is transmitted from the sensors to the online environment using two LoRaWAN gateways. Data is sent once every three hours. A dashboard ("IOT-connect") is provided that is accessible only to the City of Amersfoort, which shows an overview of current and historical data for each of the sensors or each of the sites. Figures 7 and 8 shows screenshots of this online dashboard. This online dashboard is not part of the SCOREwater platform and is used by the City of Amersfoort for monitoring and analytical reasons.

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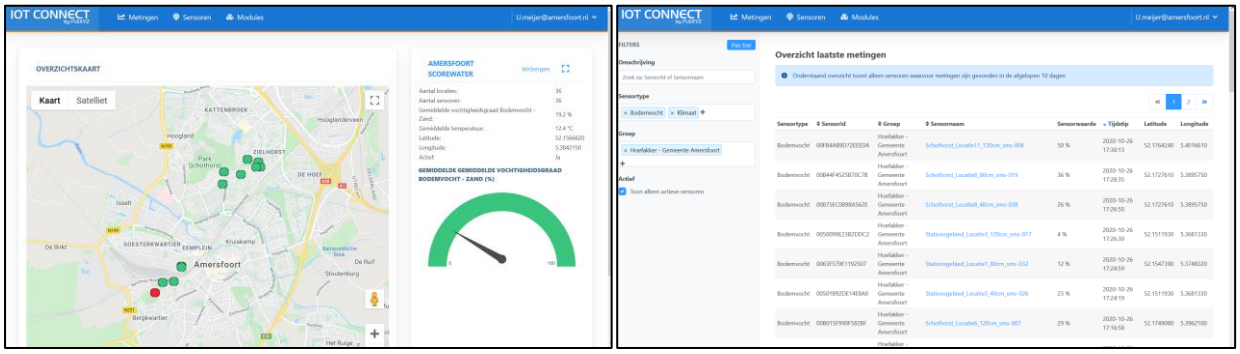

Figure 8 and 9: screenshots of the IOT-Connect dashboard, showing a geographical overview (left) and current measurements (right).

Additionally, both the City of Amersfoort and Civity have access to the raw data via a FTP-server. From this FTP server, the data will be periodically uploaded to the SCOREwater platform using an automated process. Once the data is available on the platform, the data will be harmonized using the FIWARE GreenSpaceRecord FIWARE model and become available as open data. This facilitates integration with the Measure Your City data, which will be harmonized using the same model. COA and Civity are currently working on this integration. By doing so, all interested parties can investigate, download and use the data for their own purposes.

Measure Your City has its own data platform. The Measure Your City website is accessible via www.meetjestad.net. It includes a geographical overview of all sensors, raw data per sensor / neighborhood and a function to download all data. All data gathered is open and accessible to all interested parties. The Measure Your City data will also be made available in harmonized form in the SCOREwater platform to allow for a single comparison between Measure Your City data and COA's sensor-data. Figures 9 and 10 show two screenshots of the Measure Your City platform.

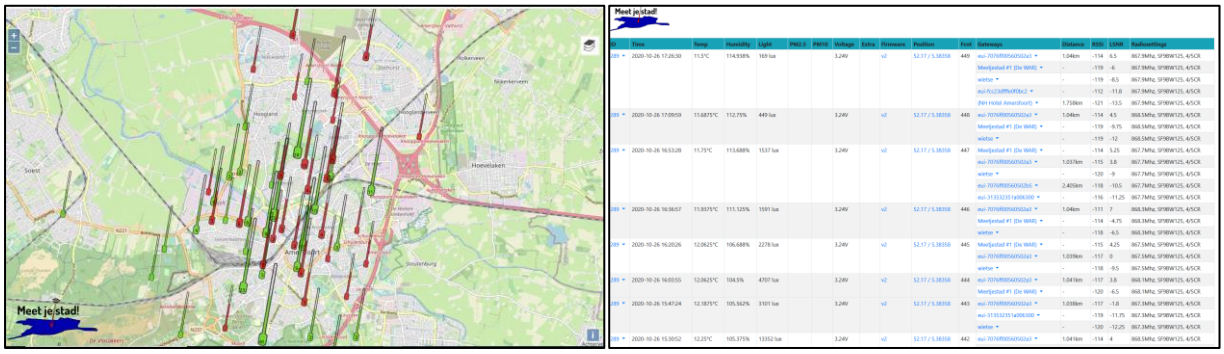

Figure 10 and 11: screenshots of the Measure Your City platform, showing a geographical overview of the active sensors (left) and data for individual sensors (right).

6. HOW THE DATA WILL BE USED

The data gathered will be used in urban planning processes. Currently, when planning for the (re)development of areas the City of Amersfoort combines model calculations with gut feeling to assess what needs to be done in areas that are going to be redeveloped. When redeveloping areas, available space is always scarce, money is always limited and ambitions are always high, causing difficulties and the necessity to prioritize. By using sensor data to analyze the current situation, COA wishes to gain more insight into the actual necessity of implementing measures to mitigate effects of climate change.

As such, there is a desire to use data to gain a more precise image of the current status of areas. This includes a more detailed image on water related issues, heat stress, draught issues and issues related to greenery. Additionally, the data will be analyzed to test assumptions about general conditions influencing the environment.

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The analysis of the data is part of the next stage of the project. Examples of research questions that will be answered by analysing the data:

- What is the influence of the type of surface on soil moisture levels?
- Does the nearby presence of surface water affect soil moisture?
- What is the influence of heat on soil moisture?
- What is the relation between groundwater levels fluctuance and soil moisture?
- Are adjustments on in public spaces (on street level) helpful to improve the soil situation for a more climate adaptive city?
- If we compare objective data on temperature/humidity to subjective data (gathered by thermal walks), what relationships can we derive? What is the influence of contextual factors (such as presence of water, buildings etc.)?
- What local differences do we see when it comes to temperature / humidity? Can we explain these by contextual factors?

7. LESSONS LEARNED

The first lessons that has been learned while deploying the sensors is that not all preferred locations have proven to be possible to include. As stated, the soil moisture sensors are placed into the ground. However, on certain locations it was impossible to dig deep enough to place the sensors because the soil was impossible to dig through. As such, several locations had to be altered to allow for the deployment of the sensors. Lesson learned here is that the only way to get this information is by trying: as such, it is important to build some flexibility in the planning.

The second lesson learned is that although the sensors purchased are low-maintenance, they do require at least some maintenance. As stated, the sensors chosen sent data every three hours. To do so, they need energy. The sensors are powered by batteries, which ensures flexibility (no power source required), but also cause higher maintenance. How much is dependent upon how often they are asked to send data. With this frequency the batteries are expected to last 1 – 1,5 years. As such, we have learned that this is an important trade-off when using this type of sensors: measuring frequency versus maintenance needed due to battery capacity.

The third lessons learned is that Covid-19 causes issues when trying to involve citizens. Specifically, currently within the Netherlands it is prohibited to organize events for large groups. This causes difficulties for Measure Your City, because an important pillar of the initiative is to build sensors together with groups of residents to involve them in the project. Measure Your City has already shifted its meetings online, allowing for some collaboration. The advantage of this is that it is now more easy to collaborate with citizens from other cities. However, involving citizens who are not participants yet is more challenging. As such, it is important to keep regular contact with all partners involved and together come up with solutions for issues should the measures taken be implemented longer.

8. REFERENCES

VASILIKOU, CAROLINA, and MARIALENA NIKOLOPOULOU. "Thermal Walks." *PLEA*. 2013.

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ANNEX 1 – STOCKTAKING

A final Annex of stocktaking was included in all Deliverables of SCOREwater produced after the first half-year of the project. It provides an easy follow-up of how the work leading up to the Deliverable has addressed and contributed to four important project aspects:

1. Strategic Objectives
2. Project KPI
3. Ethical aspects
4. Risk management

STRATEGIC OBJECTIVES

Table 2 lists those strategic objectives of SCOREwater that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 2: stocktaking on deliverable's contribution to reaching the SCOREwater strategic objectives.

Project goal	Contribution by this Deliverable
SO1: Deploy and demonstrate a smart water management approach, which is people-centred, inclusive, interoperable, flexible and safe.	The deliverable describes the deployment of several sensors, used to aid in the development of smart water management solutions. By integrating the data on the SCOREwater platform, interested parties can make use of these results.
S06: Increase citizen involvement and engagement in the transition to a water-smart, resilient society	Part of the sensors were developed together with citizens science collective De WAR as part of Measure Your City. Within Measure Your City, COA works together with citizens to work together in the transition to a water-smart, resilient society.

PROJECT KPI

Table 3 lists the project KPI that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 3: stocktaking on deliverable's contribution to SCOREwater project KPI's.

Project KPI	Contribution by this deliverable
KPI2: Number of input data-sources connected and consumed	As part of the deliverable, several data-sources is being connected to the SCOREwater-platform: data from Measure Your City, data gathered via the IOT-Connect platform and data on groundwater levels.
KPI15: Number of involved and engaged citizens in demo cities	COA works together with residents on developing and deploying sensors for Measure Your City. As such, it contributes highly to this KPI.

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ETHICAL ASPECTS

Table 4 lists the project's Ethical aspects and gives a brief explanation on the specific treatment in the work leading up to this Deliverable. Ethical aspects are not relevant for all Deliverables. Table 4 indicates "N/A" for aspects that are irrelevant for this Deliverable.

Table 4: stocktaking on deliverable's treatment of ethical aspects.

Ethical aspect	Treatment in the work on this Deliverable
Justification of ethics data used in project	N/A
Procedures and criteria for identifying research participants	N/A
Informed consent procedures	N/A
Informed consent procedure in case of legal guardians	N/A
Filing of ethics committee's opinions/approval	N/A
Technical and organizational measures taken to safeguard data subjects' rights and freedoms	N/A
Implemented security measures to prevent unauthorized access to ethics data	N/A
Describe anonymization techniques	N/A
Interaction with the SCOREwater Ethics Advisor	N/A

RISK MANAGEMENT

Table 5 lists the risks, from the project's risk log, that have been identified as relevant for the work on this Deliverable and gives a brief explanation on the specific treatment in the work leading up to this Deliverable.

Table 5: stocktaking on Deliverable's treatment of risks.

Associated risk	Treatment in the work on this Deliverable
1. Risk of delay	Due to the Covid-19-crisis, it has proven to be difficult to perform the work as planned. This is due to a variety of reasons, such as having to organize work differently due to the lockdown in March and illness of team members. Where possible, partners have collaborated closely to prevent delay.
2. Loss of Key Staff	As stated above, team members have temporarily fallen ill. Where possible, work was performed by other staff members and was organized in collaboration to prevent delay.

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