SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D3.7

REFERENCE GUIDELINES FOR THE IMPLEMENTATION OF THE SCOREWATER PLATFORM TO ENABLE REUSE AND FURTHER DEVELOPMENT

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ABBREVIATIONS

Abbreviation	Definition
API	Application Programming Interface
CKAN	Comprehensive Kerbal Archive Network
FIWARE	Future Internet WARE
ICT	Information and Communications Technology
IDM	Identity Management
IoT	Internet of Things
NGSI	Next Generation Service Interface
OGC	Open Geospatial Consortium
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprise
STH	Short Term History
WFS	Web Feature Service
WMS	Web Map Service

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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

This deliverable builds on the work done in work packages 1 (specification of requirements) and 3 (implementation of the SCOREwater platform). The SCOREwater platform acts as a broker between data providers and data users. The platform collects data from various heterogeneous sources, harmonizes these data and publishes them using multiple homogeneous open API's. The deliverable describes how an organisation can replicate the SCOREwater platform and instantiate their own instance of the platform by installing software to ingest, harmonize and store and publish data. Identity and API management are key to control access to data and prevent unauthorized access to the data. The deliverable provides functional and technical guidelines on how to collect and share standardized information from heterogeneous data sources. When setting up an urban data platform such as the SCOREwater platform within an organization, existing IT infrastructures provide both a challenge (they may not be compatible with components required to get an instance of the SCOREwater platform up and running) and an opportunity (they may already contain components such as an internet GIS server and a database which can be re-used for the SCOREwater platform). The platform relies on the FIWARE NGSI and Short Term History API's and the OGC WMS and WFS implementation specifications for publishing data. Most of these specifications work rather well for the project (the STH API could do with a next version). The deliverable concludes with sharing some experiences on building open ecosystems and business frameworks. However, since this work has a big overlap with the work being done in work package 6 this is merely the starting point of the discussion on this topic.

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1. INTRODUCTION

Within the frame of SCOREwater a platform has been deployed which acts as a broker of providers of data and users of data. The platform collects data from multiple proprietary data sources, harmonizes these data and publishes them using standardized open API's. Purpose of this deliverable is to describe how other organisations can replicate this platform and launch their own instance. The document is intended for IT staff. They may use the document to decide what software to install and how to configure this software.

This deliverable builds on several other deliverables from the SCOREwater project. SCOREwater Deliverable D1.1 "Requirement specification (hardware, software, standards)" describes the requirements for the SCOREwater platform with amongst others a list of data sources that should be connected to the platform (Corominas, Rubion Soler, Vanmeulebrouk, Hof, & Lindgren, 2021). SCOREwater Deliverable D3.1 "Functional and technical analysis of existing systems and applications with description of standards, connections and data" uses user stories to translate the requirements from Deliverable 1.1 to tasks a software engineer can actually implement and it selects software components to be used for this implementation using a simple software quality model (Hof & Vanmeulebrouk, 2021, a). SCOREwater Deliverable D3.2 "Implementation of the SCOREwater platform based on existing components, tailored by the specification delivered by WP1" describes the off the shelf software used for the SCOREwater platform (Hof & Vanmeulebrouk, 2021, b). SCOREwater Deliverable D3.3 "Integration and connection of sensors and algorithms to the SCOREwater platform including processing, storage and transformation of data to open API's" describes how the different sensors were connected to the SCOREwater platform (Hof & Vanmeulebrouk, 2021, c).

The following topics will be discussed in this deliverable:

- Functional and technical guidelines to collect and share standardized information from heterogeneous data sources (e.g., sensor measurements, building information, geospatial information, meteorological data) in section 2;
- A description of open standards, security measurements (identity and API management), privacy and ownership in section3;
- A description of technological and standardization needs, barriers and solutions, based on the gained experiences related to the development and design of the SCOREwater platform in section 4;
- A connection to experiences on building open ecosystems and business frameworks in section 5.

2. FUNCTIONAL AND TECHNICAL GUIDELINES

Figure 1 depicts the SCOREwater platform software architecture. The SCOREwater platform has three main tasks: ingest heterogeneous data from different sources (1), harmonize and store these data in a time series database and store metadata in a metadata database (2) and publish homogeneous data using standardized APIs (3) in an API management solution to be able to control access to the APIs. These APIs can be used to implement smart algorithms and data driven models and to create apps, dashboards and maps (4). This is beyond the scope of the SCOREwater platform.

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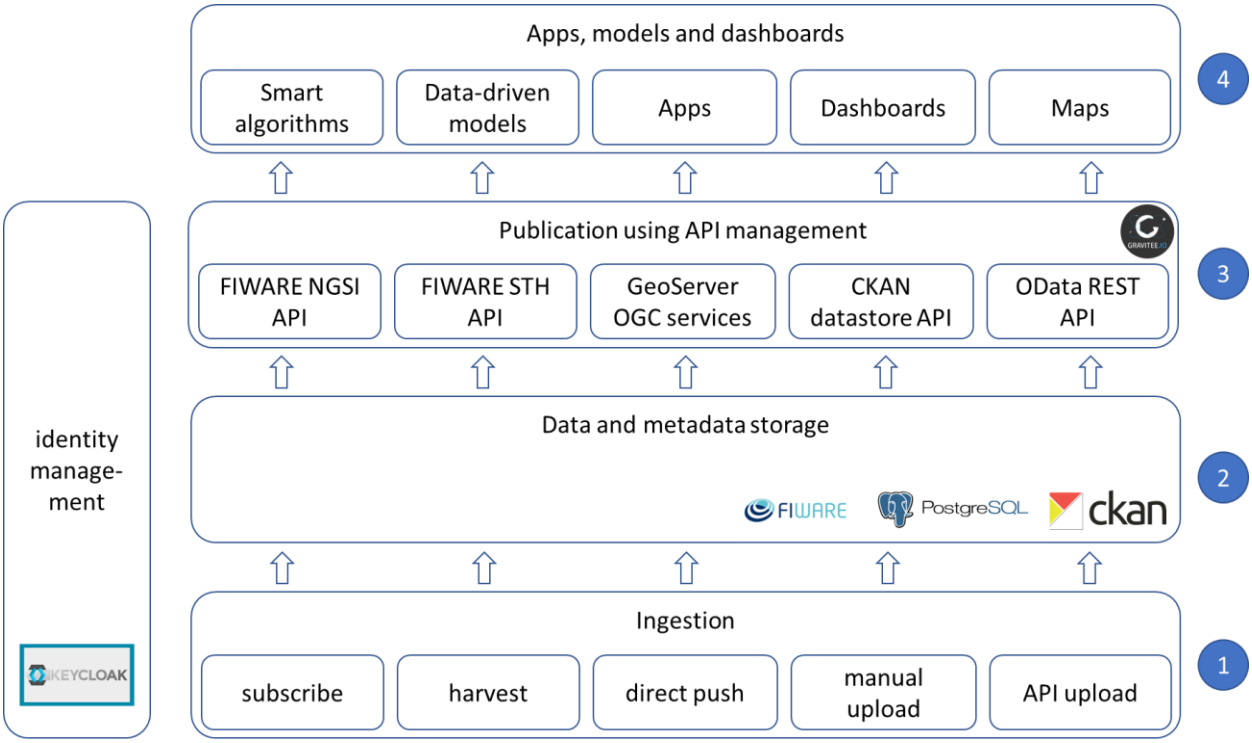

Figure 1 SCOREwater platform arcitecture

The SCOREwater platform can be replicated by installing the same open-source software components as used for the SCOREwater platform. But a similar set-up can be implemented using other open or proprietary software components. Experiences from replication efforts at the City of Göteborg show that maybe the biggest challenge when replicating the SCOREwater platform is the existing IT infrastructure which has to be taken into consideration. The existing IT infrastructure may be using components which are not compatible with the ones from SCOREwater. On the other hand, the existing IT infrastructure can also be a good starting point, it might already contain components which can be re-used such as databases, an open data portal or an internet GIS server. If for example an organization already uses an Oracle relational database management system and an ArcGIS for Server internet GIS server it is maybe not a good idea to start using PostgreSQL and GeoServer only because SCOREwater is using PostgreSQL. Maybe it is a better option to create the time series database using the existing Oracle installation and use ArcGIS for Server to publish the data in the time series database. This allows for re-using existing investments in the IT infrastructure. Deliverable 3.1 (Hof & Vanmeulebrouk, 2021, a) provides an overview of open-source software components which can be used to implement the SCOREwater platform. Table 2 in Annex 1 of this deliverable provides a list of software used to deploy the SCOREwater platform with the option the add the software to be used in replication.

2.1. INGESTION

As discussed in Deliverable 3.1 (Hof & Vanmeulebrouk, 2021, a), data providers must be able to incorporate data in the SCOREwater platform using different methods: the platform should be able to a) subscribe to different queues (for instance MQTT) b) periodically harvest third party APIs; c) receive data from IoT devices directly (direct push). Data providers should be able to upload data either manually or using an API. Ingestion entails receiving the data in proprietary format, convert the data from proprietary format to harmonized format and store the data.

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Within the frame of SCOREwater, IoT agents which can process data from IoT devices and harvesters which periodically access third party APIs to collect data have been created in the form of microservices in Java using Spring Boot and Apache Camel. Spring Boot facilitates the creation of standalone programs (such as the microservices created within the frame of SCOREwater. Camel is a framework which allows you to connect different components of a system (in this case sensors producing data which should end up in a time series database and a ContextBroker) using messages. Table 1 lists the connectors used within the frame of SCOREwater. Most datasets have been onboarded within the frame of the project, but some relevant datasets from other projects have been included as well (these have been marked as "non SCOREwater"). A replica of the SCOREwater platform does not have to support these data sources, but chances are that the same ingestion method and protocol surface when onboarding other datasets. From this table it can be concluded that the protocols MQTT, LWM2M, NGSI, SFTP and http post must probably be supported by a replication of the SCOREwater platform since the sensors involved rely on these protocols. This list is not exhaustive though, connections to for example Amazon S3 buckets or Microsoft Azure might be needed for other sensors as well, but within the frame of SCOREwater those connections were not needed.

Table 1 SCOREwater connectors

Case study	Source	Ingestion method	Protocol
Göteborg	Vatten I Göteborg (meteo)	Harvester	n/a
	SMHI (meteo)	Harvester	n/a
	Talkpool (water quality)	Agent	MQTT
	Turbinator IVL (water quality)	Agent	LWM2M/MQTT
	Swedish Hydro Solutions (water quality)	Harvester	n/a
(non SCOREwater)	Uppsala Bathing water (water quality)	Agent	NGSI
	GBG Bathing water (water quality)	Agent	MQTT
Barcelona	s::can (water quality)	Agent	SFTP
Amersfoort	Teneo (soil moisture)	Agent	SFTP
	Meetjestad (meteo)	Harvester	n/a
	Meetjestad (soil moisture)	Harvester	n/a
	Meetjestad (air quality)	Harvester	n/a
	Hydrologic Flood Early Warning (alert)	Agent	SFTP
(non SCOREwater)	"Snuffelfiets" (air quality)	Agent	http post

To demonstrate the structure of the code of IoT agents and harvesters, a small example of a "minimum viable iot agent" has been created. It consists of three modules (see Figure 2): a module with re-usable code (fiware-core) and two example IoT agents (gbg-bathing-water and turbinator).

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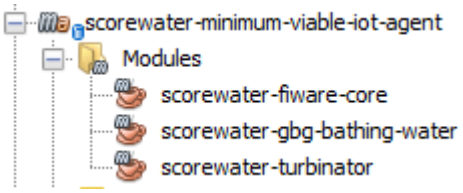

Figure 2 Structure of minumun viable iot agent

The fiware-core module contains code which is need by all IoT agents and harvesters: the Camel routes and processors, implementations of the FIWARE Smart Data Models (including the code to serialize entities encoded using those data models) and publishing to the FIWARE ContextBroker. The IoT agents and harvesters only contain the code specific to the IoT agent/harvester, usually only code to be able to process the proprietary data. And some of them even do not need that, if they are using a standardized data format. This example code (including the libraries it depends on) is available in the Civity Github repository under a BSD open-source license (https://github.com/CivityNL/SCOREwater-Java).

Alternatively, the FIWARE ecosystem offers several out of the box IoT agents which can be used as well. These IoT agents and harvesters can also be created using any programming language. The structure described in the previous paragraph can be applied in those environments as well.

Manual and API upload are provided by the CKAN open data portal.

2.2. HARMONIZATION AND STORAGE

Data ingested in the platform is stored in tables in a relational database management system (RDBMS) in raw format, as it comes in from the sensor or third-party API. Data is harmonized using views. This way of working has several advantages: it allows us to combine data from different tables in one view. For instance, a table in which data is constantly being added with the actual measurements can be combined with a table which contains static data of the sensor which hardly even changes (for example calibration factors, the location, the address or a name). Furthermore, it allows us to refer back to the original data if needed (for instance in the case of phenomena which cannot be explained by looking at the harmonized data). And it allows us to modify the harmonization later on without losing data collected in the past and support different versions of the harmonization.

For metadata, the SCOREwater platform relies on the CKAN metadata portal.

Data is stored in the PostgreSQL relational database management system. To facilitate querying time series, indexes on columns with temporal information have been created. The PostGIS extension is used for spatial information.

2.3. PUBLICATION

Data collected using the SCOREwater platform is published using various open API's. As soon as data comes in, either via an IoT agent or a harvester, it is published using the Orion ContextBroker. The ContextBroker publishes the latest state of an entity (for instance a sensor). And it allows users to subscribe to updates of those entities: they can resister a call back URL to which data is being sent as soon as it comes in. A proxy has been created for the ContextBroker to facilitate proper functioning of the ContextBroker behind an API management layer.

Furthermore, data in the time series database is accessible via the so-called Short-Term History (STH) API. The STH API in SCOREwater has been developed using Java, Spring Boot and Camel, allowing us to re-use what has been developed for IoT agents and harvesters. As a consequence, the STH API for the different data sources are available in the form of microservices.

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IoT data often contains a spatial component (for instance the location of a sensor). To be able to connect the time series database to spatial data infrastructures (SDI's), the data in the time series database is published using GeoServer, which makes the data available using the Web Map Service and Web Feature Service implementation specifications from the Open Geospatial Consortium (OGC). Most GIS software, both proprietary and open source can use those web services. A proxy has been created for the OGC services to facilitate proper functioning of the OGC services behind an API management layer. Whether this really works depends on the definition of the plans in the API management solution: not all forms of authentication and authorization required as a consequence of plans may be supported by all OGC client software.

Whereas the ContextBroker, STH API and OGC services provide access to the harmonized data in the time series database, the CKAN data store API provides access to the raw data.

All API's should provide access via the API management layer. The API management layer facilitates the Data Market or Marketplace. It basically provides the products which can be incorporated in what could be called a "web shop". SCOREwater relies on Gravitee for API management. Gravitee consists of three parts:

1. The management UI used by administrators to define and manage their API's;
2. The portal UI used by end users to manage their subscriptions (see);
3. The gateway is a non-visual component used to connect the applications created using the API's to.

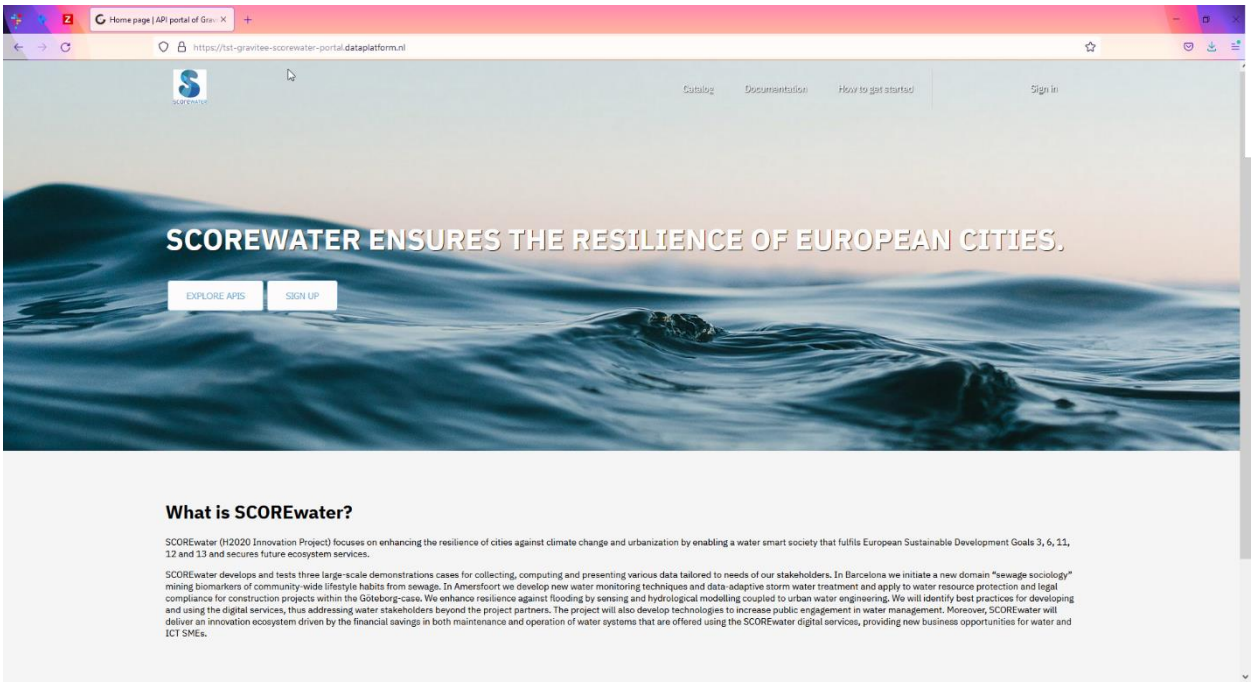

Figure 3 Front page of the SCOREwater API management portal

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3. OPEN STANDARDS, SECURITY MEASUREMENTS, PRIVACY AND OWNERSHIP

3.1. OPEN STANDARDS

The software infrastructure used to replicate the SCOREwater platform must comply with certain open standards from the IoT domain: FIWARE and the Minimal Interoperability Mechanisms (MIMs) of the Organization of Open and Agile Smart Cities (OASC). Purpose of FIWARE is to define open standards for the IoT domain, purpose of the OASC MIMs is to promote scalability and replicability of smart city solutions. In addition, to be able to connect the platform to spatial data infrastructures, the platform should provide access to the data in the time series database using the implementation specifications of the Open geospatial Consortium (OGC).

The receive the "Powered by FIWARE" seal of approval using a ContextBroker in mandatory. By using the ContextBroker, the SCOREwater platform implements MIM 1 (Context Information Management). MIM 2 (Common Data Models) is implemented by using the FIWARE Smart Data Models to harmonize information from various sources to. If a Smart Data Model is not available for the domain at hand (or if it does not fulfil the project's needs), other commonly used data models for the domain have been evaluated. The API management solution allows for connecting the SCOREwater platform to the FIWARE Biz ecosystem and thus prepares the SCOREwater platform for the implementation of MIM 3 (Marketplace Enablers).

Metadata has to be compliant with different DCAT application profiles for the different countries: DCAT-ap-SE in Sweden, DCAT-ap-DONL in the Netherlands and DCAT-ap in Spain. By implementing those standards, the metadata portal on the SCOREwater platform should be able to be part of the federative system of metadata portals in the different countries.

3.2. SECURITY MEASUREMENTS

How to set up the software infrastructure for the SCOREwater platform in a secure fashion has been discussed in detail in SCOREwater Deliverable D3.5 "Functional and technical guidelines for implementation of privacy enhancing technologies within the SCOREwater platform" (Vanmeulebrouk & Rubion Soler, 2021). This deliverable describes in detail how communication between the different components of the platform should be secured.

Deliverable D3.5 does not discuss authentication and authorization though. Authentication is verifying the identity of a user logging in to the platform, checking if he or she actually is who he or she claims to be. For this purpose an identity management solution is needed. Authorization is determining what a authenticated user may or may not do on the platform. For this purpose an API management solution is needed.

The SCOREwater platform consists of different components with their own authentication and authorization mechanisms. Instead of relying on these separate authentication and authorization mechanism it is preferable to use one dedicated identity management (IDM) solution. Using OAuth2 or SAML the different components of the SCOREwater platform are connected to IDM. If a user wants to log in they are being re-directed to the identity management solution who redirects the user back to the application upon successful login. Advantages of a centralized identity management solution for the end-user include single sign on, and for the administrator a single location to activate multi factor authentication and a connection to for instance an ADFS can be set-up in one location.

To facilitate authorization an API management solution with different plans is needed. Using plans, data providers are able to control who can do what with the data they are publishing. Defining plans is flexible, but for SCOREwater the following plans have been implemented for the different APIs:

- Sandbox plan without registration with limited quota allowing to experiment with the API (if the license of the data permits this);
- Data user plan to actually use the API. If needed the administrator should grant permission to use the API when taking out a subscription;

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- Data provider plan for uploading data to the platform which always requires permission when creating a subscription.

3.3. PRIVACY AND OWNERSHIP

How to set up the software infrastructure for the SCOREwater platform in a secure fashion has been discussed in detail in SCOREwater Deliverable D3.5 entitled "Functional and technical guidelines for implementation of privacy enhancing technologies within the SCOREwater platform" (Vanmeulebrouk & Rubion Soler, 2021). This deliverable describes in detail how data in the database should be altered to prevent unauthorized access to privacy sensitive data (using different perturbation techniques) and how data in the database should secured (using encryption).

4. TECHNOLOGICAL AND STANDARDIZATION NEEDS

The SCOREwater platform relies on a number of open standards. Their current state will be discussed is this paragraph.

4.1. NGSI CONTEXTBROKER API

The NGSI ContextBroker API is plain and simple and works rather well. The only major issue we had to work around was the integration with the API managament solution (although it is debateble wheter that is a problem of the API management solution or of the NGSI ContextBroker API). The issue relates to logging of usage: the API management solution counts the number of requests to determine usage. When creating subscriptions, the number of requests does not properly reflect the usage: subsequent callbacks bypass the API management layer and are not counted. Usage is better calculated using for instance the duration of the subscription.

4.2. SHORT TERM HISTORY (STH) API

The Short Term History (STH) API is a good API for providing access the time series data, especially because of the option to access both raw and aggegated data. The access to raw data facilitates for instance outlier detection and the access to aggegated data facilites calculation of KPI's. but it seems to be a bit stagnant. It could do with a new version to enhance it's applicability.

4.3. SMART DATA MODELS

SCOREwater Deliverablee D3.4 "Integration of smart water data models (compliant with FIWARE-models), smart algorithms and data-driven models describes" the Smart Data Models applied within the frame of SCOREwater (Hof & Vanmeulebrouk, 2021, d). The WeatherObserved, WaterQualityObserved, GreenSpaceRecord, AirQualityObserverd and Alert data models have been used. Most work really well for SCOREwater. In Barcelona, additional water quality parameters are being collected which might be useful to add to the WaterQualityObserved model. A model for harmonizing sewer information is missing.

4.4. OGC SERVICES

The OGC services are a bit old fashioned (they do not incorporate the latest REST principles yet), but they work. And since they have been around for a really long time already, there is a lot of applications available that can work with these services. The OGC is working on modernizing the implementation specifications. This work will become available for the SCOREwater platform as well once these new versions have been implemented by internet GIS server and client software.

5. BUILDING OPEN ECOSYSTEMS AND BUSINESS FRAMEWORKS

This topic has a lot of overlap with the work that is being done within SCOREwater work package 6, although they have a much broader outlook than just the SCOREwater platform. The remarks below merely serve as a starting point for a discussion which should be picked up in work package 6. There are different perspectives for looking at this topic. SCOREwater platform → urban data platform.

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5.1. MUNICIPALITY (AMERSFOORT, BARCELONA, GÖTEBORG)

Municipalities want reliable access to data steams needed for their task. Municipalities try to avoid risks as much as possible. They have different options for securing access to data streams like the ones provided by the SCOREwater platform. What the best option is depends on a number of factors, amongst others the size (and thus the amount of resources available) of the municipality.

Large municipalities might want to host their own instance of the SCOREwater platform in their own private cloud. This provides them with maximum control over the data streams (thus minimizing the risk of disruptions of vital processes beyond control of the municipality). However, since running urban data platforms is not the core business of a municipality it might not be the most efficient option. On the other side of the spectrum is a municipality which purchases an urban data platform as a service (Software as a Service or SAAS) from a platform provider. This municipality depends on the platform provider for running vital processes (which poses a risk), but does not have to invest to be able to run the platform themselves.

5.2. DATA PROVIDER (TALKPOOL, SHS, S::CAN, HYDROLOGIC)

The stance of data providers depends on what their core business is. Companies who focus on selling sensors may want to use the SCOREwater platform too. Other companies, for who the sensor is only part of their business often have a competing vertical. Why assist in promoting a product via the SCOREwater platform (and share revenue with other organisations) whereas you can also do this using your own vertical? This will only work if the SCOREwater platform generates additional revenues or reduces the effort required to deliver products to customers

5.3. SCOREWATER PLATFORM

The ambition of the SCOREwater project is to have a platform with a sustainable business model after the end of the project. Replication of the platform at other organisations reduces chances of survival since there are multiple competing platforms in that case.

5.4. PLATFORM PROVIDER (CIVITY)

The platform provider could step up and try to run a viable instance of the SCOREwater platform. In that case, the platform provider must be able to earn enough revenues using the platform to a) pass on part of this revenue to data providers, b) cover their own investments and c) make a profit. This option begs the question of governance: although the platform provider can certainly promote the platform, they are not specialists who can answer all detailed questions on the data available on the platform. As a consequence they need assistance from for instance specialists on the sensors. Alternative options for the platform provider include acting as consultant for organisations who are running their own urban data platform or provide a ”Platform as a Service” PAAS.

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ANNEX 1 – LIST OF SOFTWARE COMPONENTS

Table 2 lists the software used for the SCOREwater platform. It provides a checklist for organisations replicating the SCOREwater platform. In the third column they can fill in what software component they are going to use.

Table 2 List of software components

Purpose	SCOREwater platform	Replication
API management	Gravitee	…
Identity management	Keycloak	…
Open data portal	CKAN	…
ContextBroker	Orion	…
Database	PostgreSQL, Mongo	…
Internet GIS server	GeoServer	…
Web server	Apache httpd	…
Proxy server/load balancer	HAProxy	…
Uptime monitor	**Zabbix**	…

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ANNEX 2 – 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 3 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 3. Stocktaking on Deliverable's contribution to reaching the SCOREwater strategic objectives.

Project goal	Contribution by this Deliverable
SO2, Harmonize and improve interoperability opportunities in the water sector" and Ambition 2a: Interoperable ICT platform for the water sector	The deliverable describes a software architecture which can be applied when replicating the SCOREwater platform
SO2, Harmonize and improve interoperability opportunities in the water sector" and Ambition 2b: Harmonizing water knowledge systems	The deliverable describes open standards and refers to data models which should be applied when replicating the SCOREwater platform
SO2, Harmonize and improve interoperability opportunities in the water sector" and Ambition 4: Standardized open water data available to all, sparking data-as-a-service market	The software discussed in this deliverable can be used as the technical implementation of a Data Market based on API's

PROJECT KPI

Table 4 lists the project KPI that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 4. Stocktaking on Deliverable's contribution to SCOREwater project KPI's.

Project KPI	Contribution by this deliverable
10 - Standardization barriers identified and mitigation options demonstrated	This deliverable discusses open standards applied within the frame of SCOREwater
12 - Technological barriers identified and mitigation options demonstrated	This deliverable discusses technical solutions for implementations of the SCOREwater platform

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ETHICAL ASPECTS

Table 5 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 5 indicates "N/A" for aspects that are irrelevant for this Deliverable.

Table 5. 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 6 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 6. Stocktaking on Deliverable's treatment of Risks.

Associated risk	Treatment in the work on this Deliverable
8 - Lack of consensus on scientific, technological or business model approach	This risk did not occur
10 - Data from Cases are sparse and are not enough to apply all methods and tools	This risk did not occur
13 - Failure architecture implementation and modules integration	This risk did not occur

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