



Asset management to support urban land and subsurface management



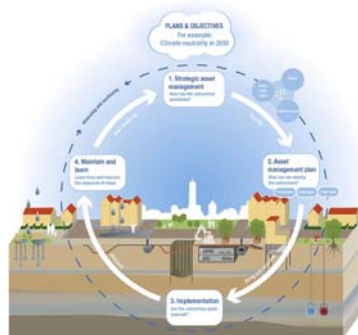
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HIGHLIGHTS

- Taking subsurface into account in urban areas avoids damage and adds value.
- Subsurface ecosystem services present value and can therefore be considered assets.
- Asset Management provides structure and transparency to subsurface management.

GRAPHICAL ABSTRACT



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ABSTRACT

Pressure on urban areas increases by demographic and climate change. To enable healthy, adaptive and liveable urban areas different strategies are needed. One of the strategies is to make better use of subsurface space and its functions. Asset management of the Subsurface (AMS) contributes to this. Asset management provides transparency of trade-offs between performance, cost and risks throughout the entire lifecycle of these assets. AMS is based on traditional asset management methods, but it does not only take man-made assets in the subsurface into account. AMS also considers the natural functions that the subsurface, including groundwater, has to offer (ecosystem services). A Dutch community of practice consisting of national and municipal authorities, a consultancy-engineering and a research institute are developing AMS in practice in order to 1) enhance the urban underground space planning (using its benefits, avoiding problems) and 2) use, manage and maintain the (urban) subsurface and its functions. The method is currently still under development.

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1. Introduction

World-wide the need for healthy, adaptive and liveable urban areas is increasing, as urban areas are growing in size and population. The proportion of the world's population living in urban areas will increase from 54% today to 66% by 2050 (United Nations et al., 2014). Next to demographic changes, climate change and the need for resource efficiency increase the pressure on the available space and the complexity to meet

the needs in urban areas. One of the solutions is to make better use of subsoil and subsurface space and its functions. In this paper, we will use the word subsurface for everything below ground level: both the upper layer (soil) and deeper layers (subsoil) of the Earth's crust, including organic and inorganic material and groundwater. Because space below surface level is inefficiently used due to lack of spatial planning, promising (combinations of) subsurface functions are not utilized or damage occurs due to unexpected effects or interferences. To avoid this, sustainable integral management of the subsurface is needed. The main goals for sustainable and integral subsurface management are: 1) prevent unnecessary damage of both the subsurface and its (future) functions, 2) optimally utilize the opportunities of the subsurface and

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3) coordinate subsurface and surface-level activities. Asset Management of the Subsurface (AMS) can be a suitable instrument to achieve integral and sustainable subsurface management.

AMS is based on traditional asset management methods, but it does not only take the traditional man-made assets in the subsurface into account (e.g. infrastructure, sewer system, underground parking garage, cables). For AMS it is investigated if assets management is applicable for the often neglected but valuable functions of the subsurface as well (ecosystem services). The Millennium Ecosystem Assessment defined ecosystem services as "the benefits people obtain from ecosystems" (MA, 2005). According to Price et al. (2016), the benefits that society derives from the use of underground space can be considered as natural capital. Natural Capital is the sum of all the assets derived from the earth's environment, including those derived from soil, which are essential for people to live.

Since 2015, a group of subsurface managers of Dutch municipalities and the National authority are working together with a consultancy-engineering and a research institute in a Community of Practice (CoP) on AMS. They aim to answer the question: (How) can asset management be a way to improve the management of urban subsurface and its functions? Their main aims were to: Avoid damage of the subsurface and its (future) functions; Coordinate soil - subsurface and surface-level activities, and; Optimally use the opportunities of the soil - subsurface and maintain its functions. To achieve these aims, they promote aware management of both traditional assets in the subsurface as ecosystem functions. AMS can offer the municipalities a method that fits to their daily practice and operational management.

This article elaborates the findings of the CoP based on the practice of two municipalities and includes the organisational aspects of implementing AMS in the municipal operational management. The method is currently still under development.

2. Asset management

Asset management, following the ISO 55000 Family of Standards (ISO, 2014), is a coordinated activity of an organisation to realize value from assets. An asset is an item, thing or entity that has potential or actual value to an individual or organisation, by providing a service. A common objective is to minimize the whole life cost of assets, but there may be other critical factors such as risk or business continuity to be considered objectively in decision making. Therefore within asset management, costs, opportunities (value) and risks are balanced against the desired performance of assets, to reach the organisational objectives. In addition, asset management enables the application of analytical approaches towards managing an asset over the different stages of its life cycle - including design, realization, management & maintenance and disposal.

In many cases municipalities already apply asset management to manage and maintain objects and infrastructures that they own or are directly responsible for, such as roads, bridges, benches and sewer systems. For example, a municipality manages and makes their choices for maintenance of roads based on analysing and balancing the risk of accidents that can occur due to poor conditions of the surface, the costs to repair the surface, optimal functioning of the road and the life-span of the surface.

3. Asset management of the subsurface

The goal of AMS is to contribute to sustainable subsurface management, by supporting decision-making during the realization, management and maintenance of subsurface functions. A new aspect is that AMS not only includes man-made assets, but also includes the natural functions of the subsurface that can be considered and managed as assets providing value.

There are examples of considering subsurface in asset management. Shah et al. (2014), discuss how the subsurface and its interaction with transportation infrastructure might be considered in terms of sustainability, vulnerability and resilience, both now and in the future. They

argue that effects of climate change demand more resilient asset management methods, which also consider the geotechnical assets (such as slopes, foundations) instead of just the infrastructure itself. It recognizes that the subsurface and constructions on and in it should be considered as a system. However, the subsurface functions such as carrying capacity are not counted as assets themselves. De Mulder and Pereira (2009) describe the beneficial function provided by the ground as a consequence of its properties and the processes that operate within it as 'geoassets'. Geoassets include functions such as provision of groundwater, natural attenuation through soils, energy and drainage. Metje et al. (2008), discuss the asset management of invisible, buried assets of utility distribution and collection networks. They advocate to locate, map and share information on buried utility services. Also Abspoel et al. (2017) focus on buried assets: pipeline networks for gas and water. They developed a model to better predict failure probability of a pipe at the required moment in time, using subsurface characteristics and variability. However, these studies were, unlike AMS, not considering the natural functions of the subsurface as assets, or they were not aimed at actual implementation of subsurface asset management in an organisation or municipal setting.

AMS is targeting local and regional authorities, active and responsible for the public area and its functions. As illustration: if a city's strategic goal is climate change adaptation, this can be translated to a task: take measures to avoid pluvial flooding. This can be achieved by increasing the volume of a sewer system but alternatively by using the water storage capacity of the subsurface. Both the sewer system and the water storage capacity of the subsurface contribute to the strategic goals and can be considered and managed as an asset.

3.1. Adjustments to asset management to be applicable to the subsurface

For AMS, some important adjustments on traditional asset management are needed:

- 1) Consider the system instead of separate objects: the subsurface is a system, containing man-made assets, such as cables and underground parking garages. It also offers natural assets (ecosystem services) with (in-) direct value for the urban environment, such as water storage and temperature buffering capacity to be used for soil energy. These (natural and man-made) functions can co-exist, compete for underground space, or interfere with each other, leading to positive or negative effects. Therefore knowledge about this system is essential.
- 2) Shifting focus from maintaining objects to maintaining functions. In urban areas, the municipality is responsible for maintaining and managing essential functions for the public: such as ensuring dry feet and a safe, clean, healthy and pleasant environment. These functions can be obtained both by man-made or natural assets. Consideration of the long term performance, risks, costs and benefits can support choices in how to provide specific functions with natural solutions, civil engineering or a mix.
- 3) Private versus public asset management. With traditional asset management, assets are generally managed by a public or private entity that is aware that it is responsible for managing and maintaining the asset and has direct benefits from this. This is often not the case in urban areas for functions of the subsurface. The subsurface and its functions that local authorities can utilize are often located in public area. However, the subsurface also accommodates privately owned assets such as cables and pipes. Also land ownership (privately owned land in urban areas) influences the ability of local authorities to make use of subsurface functions. This demands consideration of the distribution of costs and benefits of the management of subsurface assets and good interaction with stakeholders.
- 4) From lifecycle to land cycle. Where man-made assets have a specific life time and are considered from construction to disposal, functions of the subsurface are already there and when maintained well for "eternity". They do not need to be constructed and cannot be

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