Asset management of the subsurface

Can asset management be a new way to manage subsurface functions?

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ABSTRACT: The pressure in urban areas increases by demographic and climate change. To enable healthy, adaptive and livable 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) can contribute to this. AMS is based on “traditional” asset management methods, but it does not only take the “standard” assets in the subsurface (e.g. sewer system, underground parking garage, cables) into account. AMS also considers the services that the subsurface, including groundwater, has to offer as an asset (ecosystem services). AMS can be used 1) to employ the subsurface in a sustainable way within urban spatial planning (using its benefits, avoiding problems) and 2) to manage and maintain the (urban) subsurface and its functions.

1 INTRODUCTION

World-wide the need for healthy, adaptive and livable urban areas is increasing, as urban areas are growing in size and population. Next to demographic changes, climate change and the need for resource efficiency, continue to 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 subsurface space and its functions. Unfortunately, much of the subsurface value is already lost because space is inefficiently used due lack of spatial planning, promising (combinations of) soil functions are not employed or damage has occurred 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 exploit the opportunities of the subsurface and 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 “standard” assets in the subsurface (e.g. sewer system, underground parking garage, cables) into account. AMS also considers services that the subsurface, including groundwater, has to offer (ecosystem services) as an asset. The Millennium Ecosystem Assessment (MA) defined ecosystem services as "the benefits people obtain from ecosystems”.

For example: when the strategic goal of a city 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 also 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.

Since 2015, a group of subsurface managers of Dutch municipalities, 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? This article elaborates the findings of the CoP based on the practical situation and includes the organisational aspects of implementing AMS in the municipal operating procedure.

2 ASSET MANAGEMENT

Asset management, following ISO 55000, is a coordinated activity of an organization to realize value from assets. An asset is an item, thing or entity that has potential or actual value to an organization, 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 organizational 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.

Municipalities often already apply asset management to manage and maintain objects and infrastructures that they "own" or are directly responsible for e.g. roads, bridges, benches and sewer systems. For example, a municipality manages and makes their choices for roads, based on analyzing and balancing the risk accidents can occur due to 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. AMS not only includes anthropogenic assets, but also includes the natural functions of the subsurface that can be considered and managed as an asset providing value. AMS is targeting on local and regional authorities, active and responsible for the public area and its functions. For AMS, some main adjustments on the "traditional" asset management are needed:

1) Consider the system instead of separate objects: the subsurface is a system, containing anthropogenic 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 anthropogenic) 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) 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 save, clean, healthy and pleasant environment. These functions can be obtained both by deploying anthropogenic 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, mainly assets are managed by a public or private entity that knows that it is responsible for managing and maintaining the asset and has direct benefits from this. In most cases this is not the case in urban areas for functions of the subsurface. The subsurface and the functions of it that local authorities can deploy 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 employ 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 assets have a specific life time and are considered from construction to disposal, functions of the subsurface are just there, when maintained well for "eternity". Therefore they should be considered using a land cycle in which they perform their role (Figure 1). Land is either is use or in transition. The three land management phases consist of "anticipating change", "make the transition" and "check performance". Project phases that can be connected with asset management tasks are initiative, planning, realization, maintenance. Notice that the disposal of the asset is deliberately left out of this cycle. This has strong links with points 1, 2 and 3 above.

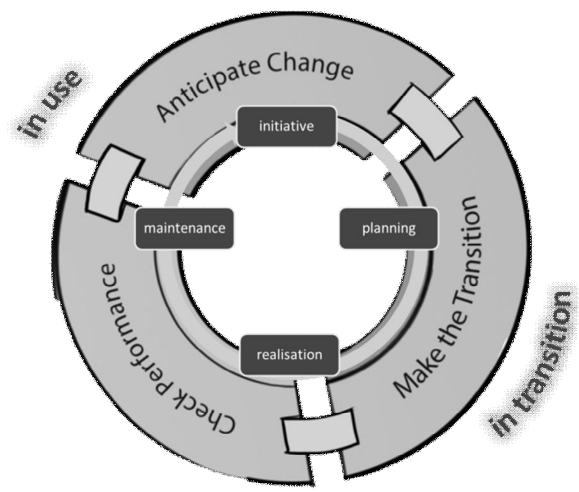

Figure 1. The land cycle for asset management (based on Ellen, 2013).

Development of AMS method by the CoP, is based on "cherry picking" tools and methods developed for traditional asset management, subsurface management and ecosystem services. Four general requirements are set by the CoP for a useful AMS method (Figure 2); it has to contribute to 1) a structured and transparent method for subsurface management, 2) cost efficiency by reducing risks and costs, but also capitalizing (in)direct value from the natural system, 3) a decision-support framework based on balancing value, risks and costs and 4) a common language for different disciplines and between different functions/levels to make options and choices understandable and transparent.

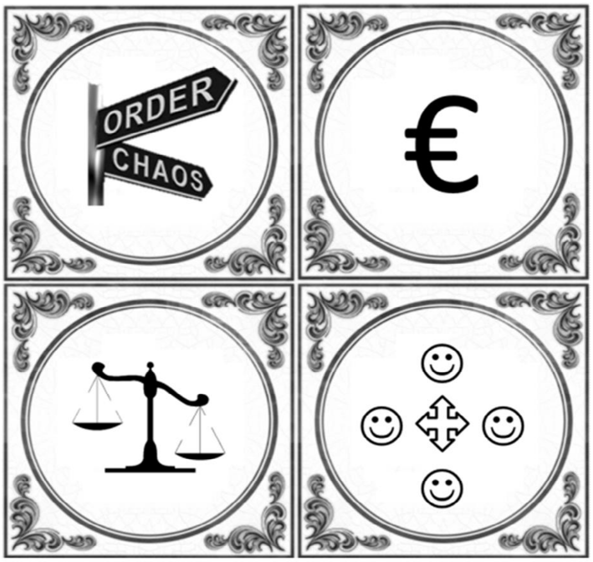

Figure 2. The four general requirements for AMS-method.

The basis for AMS is balancing the requested performance of functions of the subsurface with value / costs and risks. These main items are elaborated in more detail below.

3.1 *Performance of functions of the subsurface*

The subsurface provides different functions that contribute to healthy, adaptive and livable areas. Besides the function “space”, which is mainly used for placing anthropogenic assets, other functions provided by the ecosystem can be used. Ecosystem services of the subsurface and groundwater can be divided in four categories: 1) provisioning services (e.g. availability fresh water, energetic content); 2) regulating services (e.g. attenuation capacity of the subsurface, soil bearing capacity, storage capacity); and 3) cultural services (e.g. archaeology); and 4) supporting services (e.g. biodiversity and habitat) (Figure 3).

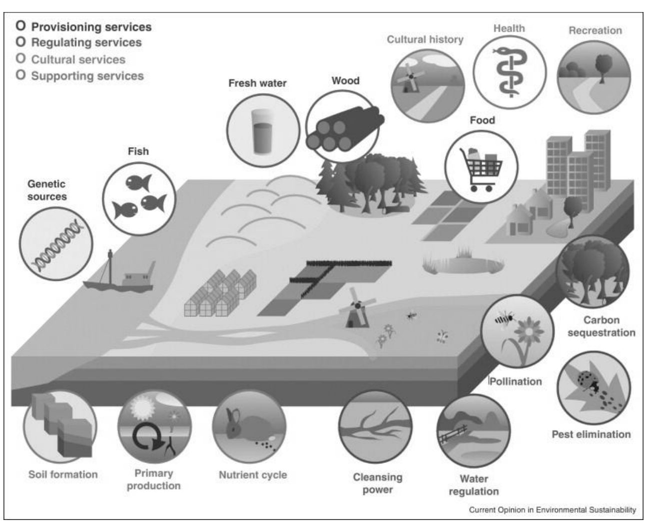

Figure 3. Ecosystem services in the Netherlands (Otte et al, 2012)

Depending on the characteristics of a location (e.g. soil type, elevation, groundwater level) and the objectives of the stakeholder(s), different subsurface functions can be demanded and obtained. The first step within AMS is to analyze, depending on the ambitions and goals, which functions of the subsurface can be employed and/or need to be maintained within an area. Consequently, the opportunities and challenges that the subsurface offers and poses need to be mapped, using area knowledge and available subsurface data and models. Different methods have been developed to systematically analyze the potential of the subsurface for the urban system. Examples of these methods are: SEES (System Exploration Environment & Subsurface) (Hooijmeijer, 2013) and Resources methodology for subsurface (Smit, 2007).

3.2 *Risks of the subsurface functions*

Within AMS risks that can occur due to the subsurface but also risks that can occur to the subsurface are taken into account. Concerning the first, when functions of the subsurface fail, this often has a direct effect on the public space and in direct costs. Failing subsurface functions can have effects such as settlements, delay in building projects, damage to cables and pipelines and flooding.

Different activities can also cause risks to the subsurface and its functions. Examples are contamination or soil sealing, disturbing the possibility to use water storage capacity by land use practices. Other commonly seen example is inefficient use of space or interferences between subsurface functions due to bad spatial planning practice (e.g. interfering aquifer thermal energy storage systems). Both categories of risks can be overcome by performing a (semi-quantitative) risk assessment during projects. Having sufficient data and information of the employed subsurface functions (both natural and anthropogenic), subsurface characteristics and subsurface potential is a requirement to be able to assess and anticipate risks, and avoid them from actually occurring. Unfortunately data and information availability (including quality) and exchange is still insufficient in most cases (Klerk, 2015).

3.3 *Cost and value of subsurface functions*

The costs of managing and maintaining anthropogenic assets placed on, or in the subsurface are high. Not knowing or taking into account the subsurface system or not managing the subsurface in a sustainable manner, involves high costs. Damage to subsurface assets often occurs due to lacking information or not using information in projects. Examples are digging damages to cables and pipelines, when not knowing where these are exactly placed during excavation works. On the website of the Dutch Government, it is stated that in The Netherlands, these repairing costs are 25 million euro per year. Another example is (preventable) damage to new-placed buildings due to settlements and flooding because local circumstances were not taken into account in the planning phase. Although the numbers are not known, not fully exploiting the potential of soil functions or irreversibly damaging soil functions can potentially "cost" society a lot now and in the future.

The value of the subsurface, when just considering the anthropogenic assets, is large. For example, the Dutch Municipal Platform Cables and Pipes (GPKL) estimated that there is about 2 million km of cables with a replacement value of 100-300 billion euro's in the subsurface in the Netherlands. When taking into account the (indirect / societal) value of functions delivered by the subsurface, this value increases significantly. UN Environment Programme initiative called "the Economics of Ecosystems and Biodiversity" (TEEB) tried to monetize the value of ecosystem services. Some ecosystem services have a concrete economic value for example provisioning services like drinking water, fossil fuels. Unfortunately most ecosystem services have an indirect value. Methods for valuing the indirect benefits of ecosystem services in monetary terms are (Farber, 2002):

1) Avoided cost: services allow society to avoid costs that would have been incurred in the absence of those services (e.g. waste treatment by wetland habitats avoids health costs);

2) Replacement cost: services could be replaced with man-made systems (e.g. restoration of the Catskill Watershed cost less than the construction of a water purification plant)

3) Factor income: services provide for the enhancement of incomes (e.g. improved water quality increases the commercial take of a fishery and improves the income of fishers)

4) Hedonic pricing: service demand may be reflected in the prices people will pay for associated goods (e.g. coastal housing prices exceed that of inland homes)

In addition to point 1 and 2, the value and degree of irreversibility and scarcity should be taken into account. When the soil and its functions are not planned, used and managed in an optimal manner, potential and future value can be lost. Because subsurface is a slow responding medium, this loss can be irreversible and scarce and irreplaceable subsurface functions can disappear. In addition of point 3 and 4, the fact that many subsurface functions can be combined with other services should be considered in determining value.

Different studies have been performed to monetize ecosystem services, but putting numbers on the above mentioned values can be difficult and all stakeholders should agree on them. A second difficulty is the division in costs and benefits. Trade-offs can be made on different aspects, but again this is location specific. Therefore within AMS the costs and values of functions are semi-quantified by stakeholders in the area, taking into account parameters as irreversible, scarcity and multi-functionality.

4 CHALLENGES

Within the CoP different challenges in developing the method AMS came across as well as organizational aspects to implement AMS. Some challenges are described below.

An important challenge is raising awareness of the possibilities in gaining value and decreasing costs when managing the subsurface sustainably. Currently the subsurface is often seen as one of many aspects in spatial development and as a black-box with its advantages and disadvantages, where we just have to deal with. When taking subsurface functions into account with asset management for the public area, conscious decisions can be made whether the subsurface can supply the essential functions, or that this will be solved in another (civil engineering) manner. Much value can be gained and costs can be avoided when it is recognized that the subsurface is a system and asset management should be tailored to that, instead of maintaining assets of the system separately.

Another issue is ownership. For several soil functions there is no "real" asset owner or manager. Public authorities, e.g. municipalities, water boards, and provinces, are in charge by policy and regulation when maintaining and managing soil functions. Some functions such as delivering drinking water and archeology) are maintained and managed because there is regulation or a responsible party. Other soil functions, such as space, water storage capacity do not have regulation or a direct asset owner or manager. In many cases decisions on subsurface are then made on gut feelings. Question is takes or actually is responsible for exploiting, managing and maintaining these functions.

Availability of information is another challenge. To be able to implement AMS sufficient, good quality data and understandable information should be available and obtainable. In this way the potential of subsurface functions can be matched to an area's objectives.

Finally, defining the (indirect) value of the soil functions is a challenge. This is both needed for balancing performance, costs and risks in AMS as well in the communication to other parties concerning the importance of sustainable subsurface management. Factors playing a role are the degree of (ir) reversibility, possibility for multifunctional use and scarcity of the function.

5 CONCLUSION

AMS is still in development, but has the potential to become a structured and transparent method that gives insight into possibilities, the costs and risks, but also the value of the subsurface. Although it can be based on traditional asset management methods, not all principals can be followed one-on-one. Therefore it is cherry-picking from existing subsurface, ecosystem and asset management methods that can be applicable for AMS, to eventually obtain a structured, sustainable and integral subsurface management. AMS can support decision-makers when choosing between different options to solve objectives and to form well-founded decisions on if and where to take action and to invest within subsurface management. In this way, private and public investment for subsurface activities can be implemented most effectively, realizing the subsurface assets.

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