The significance of planning and management of the subsurface to achieve sustainable cities

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Introduction

The subsurface is the foundation upon which all cities rest. But the subsurface is not only a construction basis which provide physical space for infrastructure and the possibility to create a better surface living environment: the subsurface is a multifunctional natural resource. Apart from physical space, it provides water, energy, materials, habitats for ecosystems, support for surface life, and a repository for cultural heritage and geological archives. Currently, the subsurface is often utilised according to the "first-come-first-served" principle, which hinders possibilities to take strategic decisions on prioritisation and optimisation of competing subsurface uses, as well as fair inter- and intragenerational distribution of limited natural resources (Volchko et al., 2020).

A great disadvantage is the invisibility of the subsurface and consequently a lack of understanding of it as a multifunctional resource: the recently launched concept of geosystem services (van Ree et al., 2016) could help mitigate its underrating.

Method

In order to better acknowledge and lift forward the significance of the subsurface in achieving a sustainable future, the 17 SDGs launched by the United nations (UN, 2020) are scrutinized in relation to the resources of subsurface, and specifically how better planning and management of the subsurface can contribute in achieving the goals. It provides an update of the mapping done by Admiraal & Cornaro (2016).

Results

Subsurface planning and management is relevant to at least eight (3, 6, 7, 9, 11, 12, 13, 15) out of the seventeen SDGs, see Table 1. Although the subsurface is not explicitly mentioned in the SDGs (except for aquifers), the subsurface can significantly contribute in achieving several of these goals.

Conclusion

Sound planning and management of the subsurface can support the achievement of the mapped SDGs in various ways. The subsurface must be recognised as a precious and multifunctional resource which require careful planning and sensitive management in accordance with its full potential and its value to society.

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Table 1. Mapping of subsurface aspects with potential to contribute to achieving Sustainable Development Goals (SDG).

SDG	DESCRIPTION, EXAMPLES AND JUSTIFICATION
3 GOOD HEALTH AND WELL-BEING	Proper planning for protecting and managing soil and groundwater resources, as well as remediating contaminated sites can reduce the number of deaths and illnesses from water and soil pollution.
6 CLEAN WATER AND SANITATION	Groundwater is an important drinking water resource worldwide. Proper planning and management of the subsurface includes protecting natural groundwater resources from degradation (quality and quantity). The subsurface can also be used for storing water, as well as for filtering of surface water to improve quality and reduce costs for drinking water treatment. Shallow and deeper underground space is extensively used for piping systems for drinking water supply, sewage systems, underground facilities for waste water treatment, underground pneumatic waste systems etc., contributing to providing universal and equitable access to safe and affordable drinking water and access to adequate and equitable sanitation. Proper planning for protecting and managing groundwater resources, as well as remediating contaminated sites can contribute to reducing pollution for improved water quality and protecting and restoring groundwater-related ecosystems, e.g. aquifers, wetlands, rivers and lakes.
7 AFFORDABLE AND CLEAN ENERGY	The subsurface can provide renewable, carbon dioxide neutral, energy by extracting geothermal energy (from the geothermal gradient) or by extracting stored solar energy from the subsurface. The subsurface can be used for actively storing energy for extraction when needed by aquifer- and geothermal energy storage systems (heating/cooling systems). "Geo-energy" can contribute to achieve access to energy, increased energy efficiency and increased use of renewable energy (e.g. Bayer et al., 2019).
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Placing of infrastructure underground most likely improves its resilience to environmental issues such as disasters and extreme meteorological events. Construction of a) aquifer- and geothermal energy storage systems, b) underground systems for water supply and storage, c) underground pneumatic waste and sewerage, d) road and railway tunnels, e) tunnels for mass transit transportation, f) pedestrian tunnels, g) tunnels for transport of goods and energy, h) underground parking, i) underground railway and mass transit stations, j) navigation canals, k) hydropower underground stations and tunnels, l) nuclear waste storage and hydrocarbon storage can support achievement of development of high-quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, and to support economic development and human well-being. Competition for space underground calls for sound planning and management.
11 SUSTAINABLE CITIES AND COMMUNITIES	Efficient urban planning and management practices should include strategic decisions on getting access to underground resources in the early planning stages. Redevelopment of contaminated sites may contribute to creating jobs and prosperity without straining land and resources as well as improving resource use and reducing pollution and poverty. Urban road tunnels, railway tunnels, pedestrian tunnels, underground parking, underground railway may provide access to safe, affordable, accessible and sustainable transport systems for all. Careful planning of the subsurface may strengthen efforts to protect and safeguard the world's cultural and natural heritage, because the subsurface is, among other things, a repository for cultural heritage and geological archives. Underground transport infrastructure and underground pneumatic waste collection systems may reduce the adverse (per capita) environmental impact of cities, including air quality and municipal and other waste management. Strategic decisions on getting access to underground resources in the early planning stages may facilitate implementing plans towards resource efficiency, mitigation and adaptation to climate change, resilience to disasters.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Since sustainable consumption and production aims at "doing more and better with less," net welfare gains from economic activities can increase by reducing resource use, degradation and pollution along the whole life cycle, while increasing quality of life. Strategic decisions on getting access to the underground resources and utilisation of the various subsurface functions may promote resource and energy efficiency, sustainable infrastructure, and providing access to basic services, better quality of life for all. Subsurface planning and sensitive management of underground resources may help in achieving the sustainable management and efficient use of natural resources. Contaminated sites can be considered as land being in transition towards beneficial use. Their remediation and redevelopment will minimize consumption of greenfield land; help in achieving environmentally sound management of chemicals; and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment. Reuse of abandoned natural or constructed underground space, as well as reuse of treated masses from remediation of contaminated sites may reduce waste generation and consumption of virgin materials.
13 CLIMATE ACTION	The subsurface can be effectively used to provide better resilience towards climate change impacts and thus may strengthen resilience and adaptive capacity to climate-related hazards and natural disasters: using the subsurface's natural function for infiltrating and storing water, or constructing underground space to store storm water; even tunnels that combine storm water management and transportation. Further, the upper subsurface is a natural sink of carbon dioxide by providing habitat for vegetation and living organisms, and the deeper subsurface can provide space for storage of carbon dioxide underground and may thus mitigate climate change. Acknowledgement of these subsurface aspects in national policies, strategies and planning may facilitate integration of climate change measures and increase awareness, institutional capacity on climate change mitigation and adaptation.
15 LIFE ON LAND	Remediation of contaminated sites may restore degraded land and the soil and reduce the degradation of natural habitats, halt the loss of biodiversity. Consideration of remediation in the early planning stage may assist in integrating ecosystem values into local planning and development processes.

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