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Viewpoint

Grounding Environmental Sciences: The Missing Link to the Urban Underground

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In 1967, Professor Harrison Brown published an opinion piece in *Environmental Science & Technology* entitled "People Might Enjoy City Life".[1] The piece predicts the rapid city development witnessed over the 50 years since its publication, with the concomitant demand for fresh water, waste disposal, loss of biodiversity habitat, air and noise pollution, and heat waste. The quote concludes with a rather blunt message: "*I believe our cities as they now exist both physically and politically are doomed. I believe further that technological developments can greatly change this picture*". These words have proven to be true and are now heavily reflected in the push toward sustainable city development in lieu of the United Nations Sustainable Development Goal 11 "Sustainable cities and communities",[2] with a focus on sustainable energy generation, resource reclamation and reuse, pollution abatement,and recycling.

The urban underground space (UUS), the space that is below the soil surface, is a key volume of a city that influences urban form and development. It can be described as "*A geo space beneath urban areas, including wider areas of UUS that provide direct services to a city, e.g. groundwater supply or geothermal energy. UUS encompasses geologically formed rocks and soils, and artificial spaces, as well as caverns of various origins*".[3] Below ground environmental resources include groundwater, stormwater, soil, flora, fauna,and minerals, and a geoscientists' knowledge of geological settings and water resources can point urban planners to areas below the surface that are more amenable for development. The volumetric properties of the UUS can be exploited in two ways: first via extraction (space, materials, and water) and second via injection (construction materials, CO_2 and heat).[4] The role the UUS currently plays, and can play in the future, to make cities more sustainable has not been fully recognized. Building below the ground is just as critical as building above it and the UUS literally provides the foundations to cities. Subsequently, the UUS can support better utilization of public transport services, strengthened urban community multifunctionality, and reduced energy consumption, all of which can contribute to a well-functioning city life.

The relevance and potential exhaustibility of urban space below ground has been recognized by geoscientists of varying disciplines, reflected by the growing body of academic literature mapping geological data for holistic urban planning. This has coincided with a growing environmental science scholarship related to ecosystem services in the environmental sciences. Ecosystem services are defined as "*The benefits people obtain from ecosystems. These include provisioning services; regulating services; supporting services and cultural services*".[5] The ecosystem services principle is one of the first global initiatives that provides a new method of thinking for environmental scientists. Considering ecosystem services allows benefits that natural systems provide to society to be characterized qualitatively and valued quantitatively. This means different options can be weighed against each other and as the ecosystem services perspective becomes more mainstream, the impact of environmental processes on society, are thus bought into focus.

In the urban underground these services interface with the built environment. Underground specialists appear to have taken a first step to address this via the introduction of the

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concept of "geosystem services" which facilitates better integration. Geosystem services have been described as "*benefits to humans derived from the subsurface*"[6] and can be considered as an extension of the ecosystem services approach. They are delineated from ecosystem services by scale and time whereby geosystem services include the flow of natural resources from stocks that have been built over geological time. However, without a better integration of environmental sciences and cross disciplinary conversations, development of the urban underground has the potential to result in geosystem and ecosystem disservices. Alteration of the underground thermal environment, resultant changes to groundwater flow systems, a loss of biodiversity, the introduction of contaminants, and degradation of soil structure, are all possible negative consequences.

Harnessing these geosystem and ecosystem services in the most beneficial way requires interdisciplinary harmonization, understanding and aligning processes, their spatiotemporal scales, and environmental impacts. Environmental scientists can contribute their knowledge related to geological settings and water resources in order that underground developments are built in appropriate locations and do not negatively affect natural resources.

If environmental scientists also look through the underground lens, they will be able to contribute to an overall improvement of the urban environment and people will "enjoy city life" that is cleaner, more biologically diverse, and more sustainable in the long term.

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Notes

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