Responsible Geosciences, or Geoscience Literacy for Urbanites

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Abstract

Urbanites, i.e., people living in urban environments, should be geoscience-literate. Them living under a*'veil of geo-ignorance'* is not a valid option for responsible geosciences. The urban realm is a social-ecological system on a planetary scale. Its complex-adaptive dynamics couple human practices and the geosphere (e.g., buildings, mines, shipping), causing massive fluxes (e.g., energy, water, materials), implies extensive civil-engineering works (e.g., housing, transport, infrastructure), and applying geoscience expertise. (e.g., foundations, drainage, position) A well-functioning urban realm requires professionals, who design, build and govern it, to use geoscience expertise. Urban environments emphasise socio-economic interactions of people sheltered from everyday geosphere phenomena (e.g., weather, climate, slope-stability) and many disasters (e.g., floods, storms, heatwaves). However, most people have little insight into how much urban lifestyles depend on geosphere functions. That ignorance is a systemic risk for modern societies, which geoscience professionals should mitigate, and meteorology gives an example of 'how'. Modern meteorologists combine weather forecasts with information on meteorological phenomena, climate change, and impacts on economic and social activities. They show how weather forecasts determine people's work and life, demonstrating the wealth of geoscientific information and professional practices. The yet-to-answer question: How to do alike?

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Introduction

An aspect of sustainable urban life is the role of geoscience literacy. This essay argues that geosciences literacy is relevant, particularly for urban people. Here the term geosciences shall englobe all STEM disciplines of Earth's non-living material phenomena, e.g., Geology and Meteorology. Geoscience literacy refers to insights into aspects of geosciences in terms of ideas that the public should grasp [1][2][3].

Urban life is profoundly interlaced with the geosphere[4][5], i.e., Earth's non-living material phenomena (hereafter, 'geoscientific phenomena'). Often, the interlacing is invisible because material/technical environments (technosphere) manage it [6][7]. Although, for example, slope stability risks can be accentuated in urban areas[8], urban environments are built to protect people from geoscientific phenomena and to emphasise social interaction. Therefore, urban people experience the intricate relationship between urban life and geoscientific phenomena in a moderated manner [9][10]. Consequently, urban people's cultural, economic, social, and political choices risk happening under a 'systemic veil of geoscientific ignorance'. Such ignorance is a risk – for urban people and people living in rural environments - and overcoming it is an educational challenge. Consequently, geoscience literacy [1] should be promoted so people can consider the intricate relationship [11] of their lives with geoscientific phenomena.

Nowadays, most people live in urban areas, which form an interconnected realm of metropoles, cities or towns dispersed over the globe [12]. The concept of an urban realm should not be reduced to the physical environment, such as geomorphology and hydrology, and the whole engineered environment, including buildings for housing and work, infrastructures above and below ground, and managed open spaces. Instead, the concept of an urban realm acknowledges that life in urban areas is complex and multi-dimensional, shaped by various social, economic, and environmental factors [13], which together function as complex-adaptive social-ecological systems[14][15][16][17].

As we stand at the intersection of increasing global urbanisation and pressing planetary-scale anthropogenic change, we should emphasise the ties between urban people's lives and the planet's dynamics. The urban realm is the dominant human niche [18][19]. Therefore, inhabitants of urban environments, colloquially referred to as urbanites, should be geoscience literate. Residing under a veil of 'geo-ignorance', i.e., being oblivious to the interplay between the ways of urban living and the geodynamics of the Earth System, is not sustainable. Therefore, this essay explores what geoscientists could do to develop geoscience literacy, taking urbanites as an example.

Concepts and Materials

Geographically, the realm of urban life extends beyond the perimeters of built-up urban areas[4]. Essential functionalities must be built outside urban areas to make urban life possible. These functionalities include, for example, energy supply, drinking water supply or wastewater discharge. Also, raw materials and manufactured goods, including food, must be transported into or from urban areas or, at the end of their lifecycle, be discarded or recycled, locally or elsewhere globally. Hence, regional, continental, and global infrastructures are part of the urban realm. Cultural concepts and social institutions twin these technical functionalities, which narrate the 'why', 'what' and 'how' describing them. A prominent example is the roles of public and private urban transport and the infrastructures enabling it.

The urban realm embodies a massive intersection between human activities and the geosphere implemented at local, regional and planetary scales. Moreover, the urban realm, already now of planetary reach, will expand further because many cities and regions will undergo significant growth and infrastructure investments in the coming decades. More people will live urban lives, so their appropriate literacy is crucial, and the urbanite will be the hegemonic *Anthropos* driving global change. Because the urban realm has intertwined material and immaterial attributes, analytical frameworks like geoscience literacy that combine them are needed.

Conceptual Matter: Engineering socially enacted activity

Engineering and geoscience expertise is vital for the functioning of the urban realm, for example: to shelter from hazards, to limit dependence on the natural pace of Earth's dynamics, to appropriate and process resources, or to facilitate social interaction. For example, engineering urban transportation systems applies geoscience expertise, such as engineering geology for tunnelling or hydrology for drainage systems. Engineering developments shape the material externalities of the urban realm, combine economic activities and natural processes, and connect human activities with the geosphere. Only some are as massive as, for example, flood barriers [20][21]. Many are hidden underground, like mines or pipelines [22].

The concept of engineering refers to more than the technical features of a tangible object (e.g., building or infrastructure) because it also implies addressing issues of 'why', 'what' and 'how' [23]. Given that the urban realm is an intersection between human activities and the geosphere, 'engineering' is one example of a socially enacted activity that shapes this intersection by applying geoscience expertise. For example, the why', 'what' and 'how' of civil engineering of urban developments, such as bridging a river downtown or housing developments in floodplains, illustrates how geoscience expertise is applied [24]. To detail the latter: a river basin's characteristics and operation must adhere to geomorphology, hydrodynamics, safety rules, and societal needs such as electrical power supply, irrigation, flood control, and leisure activities.[25] Operating a river basin upstream, downstream and in a city involves value-driven choices, opportunities and risks for different social groups and often impacts distant constituencies. The resulting engineering development is an integral part of the urban realm, including the cultural, social, economic and political processes that determine the choice of a given infrastructure, technology or operations and its specific intersection with the geosphere.

Multiple infrastructures are built to make the urban realm work, for example, by providing access to resources, commodities, goods, or services. In this context, civil engineering works (e.g., power plants, waterways, and tunnels) are

visible interconnections between human activities and the geosphere. Less visible coupling of human activities and the geosphere happen through the exchange of matter and energy. Generalising, socially enacted activities like engineering intersect human activities with the geosphere. Geoscience expertise is vital to making these intersections work.

Conceptual Matter: Human Niche & Urban Realm

The physical changes we can observe now in the geosphere (e.g., climate change) directly result from people's normative and value-driven decisions on how to build the planetary human niche [26][27]. The general concept of 'human niche' depicts the protected spaces humans constructed for living in the past and now [28], i.e., the various social-ecological systems of being human on planet Earth. In our time, the urban realm is the dominant variant of the human niche, measured in terms of the number of people or the size of the technosphere [29][19]. The concept of a social-ecological system [30][31] is a theoretical framework to describe the metaphorical term 'human niche'´. Social-ecological systems often exhibit complex-adaptive dynamics [32][33], i.e., they show emerged properties and cannot be decomposed in separable sub-systems, for example, in a system of material versus a system of intangible attributes.

The urban realm is the primary mode of human-geosphere interaction, shaping people's experiential connections with the geosphere. Urban environments enable people to mainly focus on the socio-economic interactions sheltered from direct exposure to many geosphere phenomena, e.g., 'bad weather'. Urbanites' explicit connections with the geosphere are often limited to events disrupting the well-functioning engineered structures supporting their urban lifestyles, e.g., storms, flooding, blizzards, or heat waves. These biased experiences contrast with the feature that geosciences expertise is vital for building well-behaving production systems, enabling consumption patterns and an everyday life spanning work and leisure activities. Hence, an irony lies in the fact that most urban inhabitants possess only a fraction of insight into how deeply their urban lifestyles are interconnected with and dependent upon Earth's geosphere functions. As insights show [34][35][36], this systemic ignorance poses a formidable risk for modern societies, a risk that needs to be addressed and mitigated by professionals in the field of geosciences.

Example: Weather

One potent illustration of how geoscientific ignorance risks have been mitigated is provided by modern meteorology and its place in contemporary societies. The weather is an example to illustrate the role of 'geoscience literacy' in modern societies, given it significantly impacts humans' lives, whether for settlement, food, mobility, production, or battle. Weather news became a 'prime time' event decades ago, substituting individual experiences and traditional wisdom [37][38][39][40].

Since the early 1950s, regular broadcasting of weather forecasts has become common. Before broadcasting weather news, systematic weather observations were practised for centuries, supported by the development of instruments, communication technologies, and standard observation protocols and organisations. Weather reports for specialised professional audiences have been produced manually and published since the mid-nineteenth century with increasing regularity. Numerical weather forecasting has become feasible since the early 1950s. From those early days, it took half a century to build the web of providers of weather products and consumers of these products.

Nowadays, in a single narrative, the modern media combine the weather forecast with additional information. The reliability and accuracy of weather forecasts directly influence the work and life of millions who depend upon reliable, professional practices and insights on how to contextualise the weather forecast. Today's meteorologists amalgamate traditional weather forecasting with additional information on meteorological phenomena, climate change effects, and impacts on economic and social activities. They effectively demonstrate how weather forecasts influence and shape individuals' work and lifestyle decisions, illuminating the value of geoscientific information and the role of professional practices.

Discussion & Conclusion

The urban realm is a social-ecological system on a planetary scale. The planetary dynamics[41][42] accentuated in the urban realm couple human practices and the geosphere (e.g., buildings, mines, shipping), causing massive fluxes (e.g., energy, water, materials), implies extensive civil-engineering works (e.g., housing, transport, infrastructure), and applies geoscience expertise (e.g., foundations, drainage, position). A locally felt impact may have its cause in phenomena occurring at distant places. Hence, people’s geoscience literacy should be twinned with a global perspective, and urbanites’ lives offer an example. Likewise, by applying geoscience expertise, the well-functioning of the urban realm requires professionals who design, build, and govern social-ecological systems on a planetary scale. Those professionals need a public that can understand them because of being reasonably geoscience literate.

As urbanisation continues accelerating, the need for geoscience literacy amongst urbanites becomes increasingly urgent because their well-being depends on how the urban realm links into the dynamics of the geosphere. Addressing geoscience literacy requires a concerted effort from professionals in geosciences, educators, policymakers, and urban dwellers. Experiences made in modern meteorology should provide a valuable blueprint for making geoscience an integral part of daily decision-making and enhancing the public's understanding of geosciences' role in urban living.

The question remains when drawing on the example of weather/meteorology: How to apply similar strategies in other geoscience disciplines to enhance public understanding and appreciation of the role of geosciences in urban living? Going public regularly, i.e., forecasting geoscientific phenomena relevant for production, consumption, and well-being, is one of the essentials. Likely, it will be possible to plug-in weather reports, first with hydrological information [43] and related phenomena or threats to harbours because of the sea-level rise [44]. The journey towards eradicating the 'geo-ignorance' will be challenging. However, geoscience literacy should empower people (of all realms) to understand their local and global environments better, engage in informed decision-making, and contribute to the evolution of sustainable urban life.

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