Why Should Urbanites be Earth/Geosciences Literate?

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Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

Urbanites, i.e., people living in urban environments, should be Earth/Geosciences literate. The urban realm is a social-ecological system on a planetary scale. Its complex-adaptive dynamics couple human practices and the geosphere (e.g., through buildings, mines, shipping), causing massive fluxes (e.g., of energy, water, materials), implies extensive civil-engineering works (e.g., housing, transport, infrastructure). Earth/Geosciences expertise combined with engineering expertise makes the coupling happen. Hence, designing, building, operating, and governing the urban realm requires professionals using Earth/Geosciences expertise. Urban environments emphasise socio-economic interactions of people sheltered from everyday geosphere phenomena (e.g., weather) 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 Earth/Geosciences professionals should mitigate, and meteorology gives an example of ‘how’. Modern meteorologists go public daily, combing weather forecasts with information on meteorological phenomena 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 urban people's Earth/Geosciences literacy. Earth/Geosciences, often called geosciences, refer to a wide range of STEM disciplines of Earth's non-living material phenomena on which urban life depends. Earth/Geosciences literacy is about Earth/Geosciences insights for the public (Wysession et al. 2012) (Stewart and Nield 2013) (Tewksbury et al. 2013) (Meyer 2022), including providing educational resources[1]. This essay neither exemplifies specific insights nor resources but argues why, from a conceptual perspective, Earth/Geosciences literacy is particularly relevant for urban people. Furthermore, the essay asks how Earth/Geosciences disciplines could learn from Meteorology. Planetary scale anthropogenic change (Rockström et al. 2023) amplifies the need for people's Earth/Geosciences literacy, which is not the subject of this essay. Instead, it looks at the ordinary features of a planetary human niche (Ellis et al. 2016).

Urban life is profoundly connected with the geosphere (Elmqvist et al. 2018) (Donges et al. 2017b), i.e., Earth's non-living material phenomena (hereafter, 'geoscientific phenomena'). Often, the connections are invisible because material/technical environments (technosphere) manage them (Donges et al. 2017a) (Chávez et al. 2018) (Renn 2020). Although, for example, slope stability risks can be accentuated in urban areas (Scolobig et al. 2016), primarily, 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 (Bohle et al. 2017) (Bohle and Preiser 2019). Consequently, urban people's cultural, economic, social, and political choices risk happening under a 'systemic veil of Earth/Geoscientific ignorance'. Such ignorance is a risk.

Nowadays, more people live in urban than rural areas. Contemporary urban areas form an interconnected realm of metropoles, cities or towns spread over the globe (United Nations 2014), including their *'Hinterland'*. The concept of an urban realm should not be reduced to the physical environment, which includes climate, geomorphology and hydrology, the engineered environments, 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 (Wachsmuth et al. 2016). Together they function as profoundly entangled complex-adaptive social-ecological systems (Cook et al. 2012) (Termeer et al. 2016) (Head and Xiang 2016) (Biggs et al. 2021). The social milieu of the urban realm is of primary visibility. Often it eclipses the tangible physical features, i.e., geoscientific phenomena, upon which it is built. Earth/Geosciences literacy renders these tangible physical features and phenomena visible.

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 (Ellis et al. 2016) (Zalasiewicz et al. 2017). Therefore, inhabitants of urban environments, colloquially referred to as urbanites, should be Earth/Geosciences literate. Residing under a veil of 'geo-ignorance', i.e., being oblivious to the interplay between the ways of urban living and the dynamics of the Earth System, is not sustainable. Overcoming this ignorance is a task for Earth/Geoscientists, who could learn from the experiences of meteorologists.

Concepts and Materials

Geographically, the realm of urban life extends beyond the perimeters of built-up urban areas (Elmqvist et al. 2018). Essential functionalities must be built outside urban areas, in so-called rural 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 transport and the infrastructures enabling it.

The urban realm embodies a massive intersection between human activities and the geosphere, i.e., the whole of the non-living part of the natural environment. The intersections happen at local, regional and planetary scales. Within the near future, 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. Because the urban realm has intertwined material and immaterial attributes, analytical frameworks like Earth/Geosciences literacy that combine them are needed.

Conceptual Matter: Engineering socially enacted activity

Engineering and Earth/Geosciences 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 Earth/Geosciences 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 (Witze 2018) (Leonardi 2021) and other hydraulic engineering works. Many are hidden underground, like mines or pipelines (Zalasiewicz et al. 2018).

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’ (Murphy et al. 2015). 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 Earth/Geosciences expertise. For example, the why’, ‘what’ and ‘how’ of civil engineering of urban developments, such as housing developments in floodplains, illustrates how Earth/Geosciences

expertise is applied (Mazzoleni et al. 2021). To detail the latter: a river basin's characteristics and operation must adhere to geomorphology, hydrology, hydrodynamics, safety rules, and societal needs such as electrical power supply, irrigation, flood control, and leisure activities.(Di Baldassarre et al. 2019). 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. Earth/Geosciences 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 (McNeill 2014) (Steffen et al. 2018). The general concept of ‘human niche’ depicts the protected spaces humans constructed for living in the past and now (Fuentes 2017), 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 (Williams et al. 2015) (Zalasiewicz et al. 2017). The concept of a social-ecological system (Schoon and van der Leeuw 2015) (Herrero-Jáuregui et al. 2018) is a theoretical framework to describe the metaphorical term ‘human niche’´. Social-ecological systems often exhibit complex-adaptive dynamics (Preiser et al. 2018) (Otto et al. 2020a), 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 social and political attributes.

The urban realm is the primary mode for shaping people's experiential connections with the geosphere. Urban environments enable people to mainly focus on the economic, social and political interactions sheltered from direct exposure to many geosphere phenomena, e.g., ‘bad weather’, ‘flooding’ or ‘land slides’. 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 of geosphere phenomena contrast with the feature that Earth/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 shown (Liverman 2009) (Wachinger et al. 2013) (Dominey-Howes 2018), 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 Earth/Geosciences.

Example: Weather & Meteorology

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 ‘Earth/Geosciences literacy’ in modern societies, given that 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 (Lorenz 2006) (Lynch 2008) (Anderson 2013) (Bauer et al. 2015).

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. Earth/Geosciences related to Meteorology, like Hydrololgy or sea-level forecasts, follow this development.

Discussion & Conclusion

The urban realm is a social-ecological system on a planetary scale; that is, it is a firmly twinned structure of social and physical features exhibiting complex-adaptive dynamics. The planetary dynamics (Otto et al. 2020b) (Rosol et al. 2017) that are 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 Earth/Geosciences expertise (e.g., foundations, drainage, position). Applying Earth/Geosciences expertise, the well-functioning of the urban realm requires professionals who design, build, and govern social-ecological systems. Those professionals need a public who can understand them because the public is Earth/Geosciences literate.

As urbanisation continues accelerating, the need for Earth/Geosciences literacy amongst urbanites becomes increasingly urgent because their well-being depends on how the urban realm links into the dynamics of the geosphere. Addressing Earth/Geosciences literacy requires a concerted effort from professionals in Earth/Geosciences, educators, policymakers,

and urban dwellers. Experiences made in modern meteorology should provide a valuable blueprint for making Earth/Geosciences an integral part of daily decision-making and enhancing the public's understanding of Earth/Geosciencess' role in urban living.

The question remains when drawing on the example of weather/meteorology: How to apply similar strategies in other Earth/Geosciences disciplines to enhance public understanding and appreciation of the role of Earth/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 (Abrunhosa et al. 2021) and related phenomena or threats to harbours because of the sea-level rise (Christodoulou et al. 2019).

The journey towards eradicating the 'geo-ignorance' will be challenging. However, Earth/Geosciences 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 life.

Footnotes

[1] Communication by Pier Matteo Barone: https://nagt.org/nagt/past_projects/literacies.html; https://www.geosociety.org/GSA/gsa/positions/position21.aspx

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