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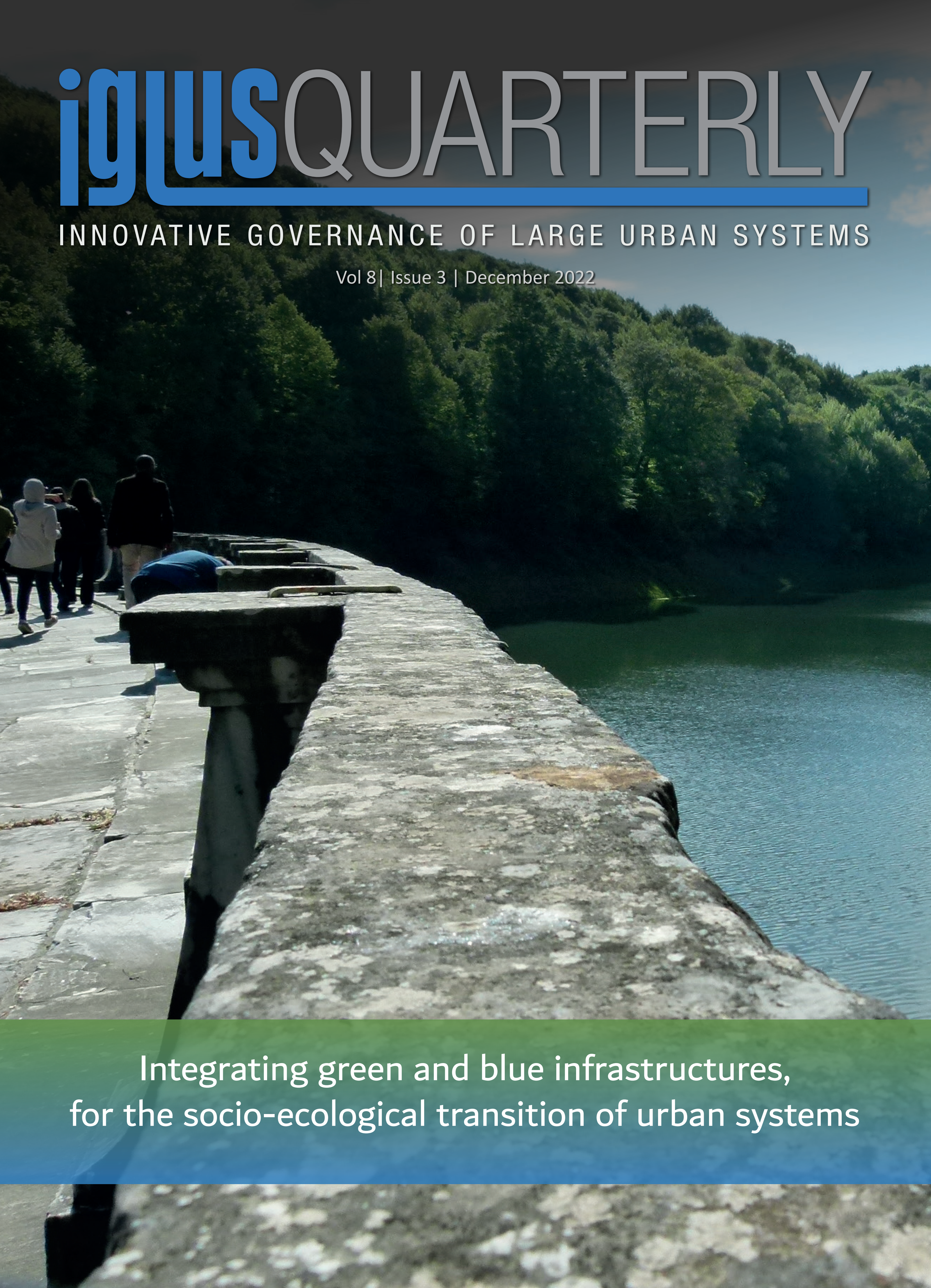

Integrating green and blue infrastructures,
for the socio-ecological transition of urban systems

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Image Credit for the Cover Page | Freshwater reservoir for the city of Istanbul dating back to the Ottoman period, in the heart of Belgrade forest, IGLUS 2016, pic. A.Finger

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INNOVATIVE GOVERNANCE OF LARGE URBAN SYSTEMS

This IGLUS Quarterly deals with green and blue infrastructures. It has three main articles, plus four illustrative inserts. Each of the articles highlights one of the three main points we think are essential when talking about urban green infrastructures:

- Andréa Finger develops the main arguments why green and blue infrastructures are central to urban spaces, for biodiversity and for their ecosystem services or contributions to society. She also shows how the definitions of the concept of green infrastructures has evolved over time to move into a more comprehensive approach and discusses scientific, technical and governance challenges for planing urban land uses to conserve and reinforce it, integrating ecological and social values.

- Matthias Finger comes from the technological infrastructures and highlights at the example of the water infrastructures, how the different infrastructures are all interdependent within an urban system, starting with water, moving on to the green and finally all other infrastructures.

- Meltem Erdem Kaya, İmge Akçakaya Waite and Başak Demireş Özkul illustrate all of the above at the concrete example of the Golden Horn in Istanbul. They highlight the social and cultural dimensions of the green and blue infrastructures for the residents, how its heritage, landscape and ecological values contribute to the attractivity of the city.

The inserts highlight the why and the how to make place for trees in cities (by Naomi Zürcher), water infiltration and flow regulation services of Northern Istanbul's urban forests (by Betül Uygur Erdogan), and urban ponds and wetlands contributing greatly to biodiversity conservation and carbon sequestration in Ankara (by Antoine Dolcerocca, Meryem Beklioğlu). Turkey offers indeed telling examples, as it is one of the emergent countries experiencing a most rapid urbanization. The third article makes the link with the IGLUS Executive Master and shows IGLUS' pedagogical approach to urban infrastructure systems having green and blue infrastructures at its core.

And this is also how we want to envision the future of the IGLUS action learning journey. While in the past we have looked at the different urban infrastructures quite separately, yet tried to show how they were linked to each other to the point of increasingly constituting one single integrated urban infrastructure system … or rather a system of systems, this conceptualization will have to evolve further:

- Green and blue infrastructures will have to take on an even more prominent role as cities are not just isolated places but are actually part of the global environment. To recall, cities are located at the places that were ecologically most rich, not just for humans but for other species as well. Therefore, cities cannot see the green and blue infrastructures solely as providing services for themselves but must also consider how they provide habitats and biological corridors to other species moving accross continents.
- At the same time, and given the global changes, especially global warming, the resilience of urban systems is becoming ever more important, which means that green and blue infrastructures have not only to contribute for mitigating and adapting to climate change but also to play yet additional roles and functions, for example when it comes to feeding urban dwellers, as well as when it comes to generating some of the energy cities consume.

Andréa Finger-Stich and Matthias Finger

The contribution of urban green-blue infrastructures to city regions' biodiversity and well-being

Andréa Finger-Stich, Ecologiecommunaute.fr

Abstract: *The history of the concept of "green infrastructure" (GI) has been co-constructed over five decades of interactions between diverse actors engaged in promoting environmentally more sustainable urban land-use and planning, including researchers of social and natural sciences, policy makers and administrators of various sectors, technicians, and managers of private and public enterprises, as well as citizens' associations promoting nature conservation, environmental education and public health. The following article recalls the process of defining GI, integrating it into environmental policy and planning processes across different scales continental, regional, city and neighborhood or community levels running across diverse administrative boundaries – from international to municipal. After being long ignored, GI has moved progressively, according to cities, from a marginal issues to first rang consideration in urban planning. Accordingly, the green and the blue bio-geophysical structure of city-regions' landscape is becoming recognized as a fundamental basis for the socio-ecological transition of urban systems. The IGLUS program has visited and analyzed over the past decade many cities' urban green infrastructures, some of which presented in this IGLUS bulletin. The following article discusses what a city can do with a robust GI, to conserve and restore biodiversity, and what GI can do in return for the well-being of urban dwellers. It raises some critical scientific and governance questions, for public, private and public collective actors to best assess, reinforce and integrate urban green and blue infrastructures into the unique context of the urban socio-ecological system(s) they are engaged with.*

Evolving meanings associated with the concept of "green infrastructure"

Recalling the original meanings, and the social contexts of their production, helps understanding the concept of "green infrastructure", the issues and conflicting interests that emerge when applying the concept in complex urban systems (Finger-Stich 2022). The term "green infrastructure" (GI) has been defined for various spatial scales, and not only for urban territories. Naumann et al. have provided a widely recognized and encompassing definition of GI, for rural and urban territories.

"Green infrastructure is the network of natural and semi-natural areas, features and green spaces in rural and urban, terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations, through the maintenance and enhancement of ecosystem services. Green infrastructure can be strengthened through strategic and coordinated initiatives that focus on maintaining, restoring, improving and connecting existing areas and features as well as creating new areas and features." (Naumann et al., 2011: 1)

This definition – widely referenced in the literature – shows that the term "green" infrastructure applies to all types of ecosystems, including "blue", i.e., fresh and marine water ecosystems, and that it can be applied also across various territorial scales.

There are localized applications of the term. Indeed, according to the US Clean Water Act, *"The term "green infrastructure" means a range of measures that use plant or soil systems. Permeable pavement or other permeable surfaces or substrates, (…) or landscaping to store, infiltrate, or evapotranspirate stormwater and reuse flows to sewer or to surface waters*" (EPA, 2019)[1]. This understanding combines the *green with the blue* part of the infrastructure, using the green (vegetation and soil) for improving the blue - regulating water cycles, managing water (in its quantity and quality). In those same terms, in 2019, the Federal Water Pollution Control Act was amended to provide for an integrated planning process, to promote green infrastructure, (…).[2]

1 EPA (Environmental Protection Agency), 2019. What is Green Infrastructure https://www.epa.gov/green-infrastructure/what-green-infrastructure, downloaded nov. 2022

2 132 STAT. 5558 PUBLIC LAW 115–436—JAN. 14, 2019. https://www.congress.gov/115/plaws/publ436/PLAW-115publ436.pdf

There is yet another term referring to this network of ecosystems that are both functional for biodiversity and for providing different services to society, which is "**ecological infrastructure**". An expert meeting organized in 1984, by UNESCO's Man & Biosphere program with UNEP, in cooperation with the USSR State Committee for Science and Technology, when discussing about ecological approaches to urban planning, used the term of "ecological infrastructure". The international experts coined the importance "to systematically record and map all wild habitats of a city, … with a biogeographical and urban zonal classification for the evaluation of habitats in the inner and outer city" (UNESCO, 1984, p.20).[3]

However, based on a large literature research da Silva & Wheeler (2017) show how the term "green infrastructure" is the most used name and suggest staying with it for communication purposes. According to these authors, the term has mostly been applied for urban settings, terrestrial ecosystems and their supporting and regulating ecosystem services, "*with a strong emphasis on the mediation of water flows, and the maintenance of species lifecycles, habitat and gene pool protection*" (p.33).

The European Commission adopted the term "green infrastructure" some years later - referring to a continental wide **planning strategy for all types of territories, rural and urban**", mostly for enhancing the effectiveness of its nature conservation policies: **"***Green Infrastructure can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings*." (European Commission 2013 :7).

This latter definition draws on Neumann's et al (op. cit., 2011), stating again that GI is made of ***high quality*** natural and semi-natural areas, A quality, which can be assessed by the areas' performance in delivering ecosystem services (to society) *and* in protecting biodiversity (for its own or intrinsic sake). Therefore, green infrastructures are assessed according to various criteria and indicators for their *ecological functionality* for nature and for their capacity to provide *ecosystem services* to society. The main rationale of this conception of the term applied to a large territorial scale, urban and rural, was to promote an EU environmental policy that allowed to increase the effectiveness of its various protected areas for the conservation of biodiversity, by connecting them through ecological or biological corridors[4]. Such continental wide networks of green infrastructures would allow wildlife populations to increase their potential habitats and to migrate for adapting to changing conditions – climate induced changes, but also due to urbanization and habitat fragmentation, to disturbing uses and pollution, or degrading feeding, reproduction, and resting areas.

The Biodiversity Information System for Europe proposes a typology of green urban and blue GI. This typology encompasses: building greens, urban green areas connected to grey infrastructure, parks and (semi)natural urban green areas including urban forests, allotments and community gardens, agricultural land, green areas for water management and blue areas.[5] But how evaluate that these diverse areas are of "high quality" ? Maes et al., propose 125 indicators to map and assess the conditions of urban green *spaces in some* 700 urban areas across the EU, evaluating ecosystems' condition, biodiversity, ecosystem services, as well as social and human health indicators. Concerning the indicators of accesibility to GI one of their findings is that "more than one out of two urban dwellers' needs to travel further than 300 m to reach a public park" (Maes et. al, 2019, p.43; Koliotsis et. al, 2020).

This short discussion on definitions shows that UGI refer to various territorial scales, urban or not, and that some focus more on biodiversity conservation, while others focus more on ecosystem services. The term of "ecological infrastructure" tends to be more nature conservation oriented, whereas the term UGI stresses more

3 The report of this same international meeting includes chapters on "urban forestry" and "urban agriculture" (UNESCO, 1984).

4 A corridor is constituted of a habitat or a conduit that maintains or enhances the viability of a wildlife population. (Hess G.R and Fisher R.A. 2001. Communicating clearly about conservation corridors. Urban Planning 55, 195-198)

5 https://biodiversity.europa.eu/green-infrastructure/typology-of-gi.

the ecosystem services provided – also called "Nature's contributions to people" (NCP)s. This latter term has been developed more recently by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services IPBES to refer not only to the market-oriented valuation of ecosystem services, but also for valuing the contributions of biodiversity to people, considering the regulating, material, non-material and optional *contributions of Nature,* and recognizing *"the pervasive role that culture plays in defining all links between people and nature"* (Diaz et. al, 2018). We will present later the example of Geneva (Switzerland) that uses the term of "ecological infrastructure" defined as " a network of natural and semi-natural habitats with high quality and functionality", (BAFU, 2021) and which will be further developed at national scale in the Swiss ValPar.ch project integrating also the NCPs concept. (Rey P.-L. et. al, 2022).

The urban GI should be connected to a larger scale infrastructure across borders, from municipal up to national and international levels. However, to have spatially and ecologically functional connections between habitats running across settled areas is particularly challenging. And with extending urbanization the urban green and blue infrastructure becomes particularly important for the functionality of the larger scale ecological network. Taking the metropolitan scale helps then to integrate the green and blue infrastructure with the other city's grey and brown infrastructures and to plan the densification of the built structure for avoiding urban sprawl – and with it, inefficient use of land, natural resources, includ-ing energy.

With over half of the population (70% in Switzerland) living in urban areas, cities become the greatest net consumers of land and water resources and producers of emissions and other sources of pollution. Cities thus become also key players in climate mitigation and adaptation measures, as well as in biodiversity conservation. The metropolitan scale allows to address a population's common living basin, depending on a watershed's water resources, a shared set of environmental conditions, and a territory's history organizing land and water uses. The city-region scale is also more convenient to address issues of accessibility to ecosystem services, for quality of life and public health – understood in physical, mental, and social terms. The governance of agglomeration wide, or city-regions' areas - including surrounding rural territories - is also better suited than are national institutions for resolving land use conflicts and involving local actors in developing adapted and integrated solutions.

Developing the **resilience** of cities requires careful planning of their green and blue infrastructures. Seeking solutions for mitigating and adapting to global changes close to the source of emissions can also provide jobs and other socio-economic benefits to cities, and it fosters "learning our way out" or culturally transformative changes engaging urban dwellers. Delivering ecosystems services "at the door" of over half of the world's population is one of the aims of urban forestry professionals working at increasing urban tree canopies.[6] Indeed, wooded areas are particularly effective at absorbing and stocking carbon (Jonard et al, 2017) and so are wetlands and ponds (see article by Antoine Dolcerocca, in this bulletin). To compensate for carbon emissions from cities, the protection of urban edges with woods, wetlands and high-quality aquatic ecosystems is highly recommended (Davies et al., 2017 and Uygur Erdogan, in this bulletin). Also, rural farming and forested areas around cities gain an enhanced value for the multi-functional services they provide to the region's urban and rural metropolitan area. The valuation of their farming and forest communities' work for protecting and enhancing the quality of the land and water resources of the territory gain in political momentum. But the institutions to govern, regulate and fairly share the costs and the benefits of this work within the metropolitan areas need to be further developed.

The urban GI for biodiversity

A "green infrastructure" for a given territory can be identified by evaluating both, its biodiversity (diversity in habitats, species, populations and genes), and its

6 https://treesincities.unece.org

ecosystem services including: *provisioning services* (food and water, etc.) ; *regulating services* (mitigation of floods, drought, land degradation and disease) ; *supporting services* (soil formation and nutrient cycling), and *cultural services* (recreation, aesthetic, spiritual, and other non-material benefits*).*[7] For instance an old oak can be the habitat for up to 300 species (mammals, birds, insects, fungus) and will - thanks to its large foliage surface - be effective at filtrating and cooling the air, its great biomass contributing at stocking carbon, its extensive root system at holding soil and contributing to nutrient cycling.

According to the Global Assessment Report on Biodiversity and Ecosystem Services *"biodiversity is declining faster than at any time in human history"* (IPBES, 2019) the first driver of massive extinction loss is changes in land uses. Agricultural expansion remains the primary factor of changes in land use, but it is followed by urbanization, as urban areas have doubled in size since 1992. Protected areas in remoter natural areas are not sufficient to inverse the trend. Also, cities are most often built-in areas which were, prior to their urbanization, comparatively among the richest in terms of biodiversity. Many still have precious habitats for fauna and flora. As an example, there are about 300 bird species in Istanbul, among which many are migratory birds. Istanbul metropolitan area has more than half of the bird species found in Turkey, of which about half are breeding in its area.[8] Therefore, if cities integrate an ecologically functional green infrastructure, they can substantially participate in reducing regional and global biodiversity extinction rates.

The concept of "green infrastructure" as a network, builds on landscape ecological theory according to which "habitat fragmentation" is a major factor impairing an ecosystem's functioning, therefore leading to the combined loss of biodiversity and ecosystem services, such as water provision and flood control.

Istanbul's third bridge over the Bosphorus near the Black Sea and related new motorways, connected to the third airport of the city, one of the biggest in the world, built in 2018 . These new transportation infrastructures meant the loss of over 6000 ha of state-owned forest - cut out of a total 7600 ha project area. The new motorways and nearby developing settlements are further fragmenting the Northern forests (Belgrade Forest) which was conserved since Roman and subsequently Ottoman times, also for being the city's major resource of water.

Third Bridge in construction, on the Bosphorus near the Black sea (Picture A.F, 2019)

According to FAO urban forests are a key element in the urban and peri-urban green infrastructure. The term is of interest because it takes an urban ecology approach whereby all trees, be they forest trees, street- park- farm- trees are part of. "Urban forests are *networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure reaching rural and urban areas and ameliorates a city's environmental footprint.*" (FAO, 2017, Urban and Peri Urban Forestry, https://www.fao.org/forestry/urbanforestry/87025/en/, consulted 30 oct. 2022).

Naomi Zürcher (2022 and see insert), further opens this definition to an urban exosystemic approach, and gives scientifically and technically tested approaches for considering the particular needs of trees in the stressful urban environment they are growing in.

7 The Convention on Biological Diversity defines biological diversity in Article 2: "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." https://www.cbd.int/convention/articles/?a=cbd-02

8 Gezgin, C. (downloaded in June 2022). Birds of Istanbul. http://howtoistanbul.com/en/birds-of-Istanbul/8560#

Also, urban forests, as well as aquatic habitats, are often key elements of what is called the "dark infrastructure". To assess the functionality of the green and blue infrastructure, the spatiality and quality of its nocturnal ecological network is key indeed. Diurnal animals need dark nights to find rest, and nocturnal animals' vision is adapted for them to see and be active at night. For instance, bats need it dark for hunting and migratory birds for orienting themselves by observing the stars. Flying insects, fish and turtles are attracted by light, but get then trapped by it, which increases their predation. Fireflies and amphibians disappear as their communication and reproduction get disrupted with exposure to artificial light (Sordello et al., 2021). Even plants are affected by artificial light, also for its impact on pollinators. Furthermore, medical research shows that light is also a pollutant for humans, disrupting sleeping patterns and neurological regeneration.

The GI for the well-being of city-regions' residents

Well-being can be defined in individual, social and environmental terms. Hence, the concept of "One health" has been increasingly used in the context of the COVID pandemic, demonstrating that health is a shared asset to care for, not only across human communities but including also other species, domestic and wild, as well as the entire socio-ecosystems they depend upon (Barthod, Zmirou-Navier, 2019). When considering human health and the contribution of the green infrastructure to it, the literature includes considerations of physical, mental and social health (along with the WHO definition of health in van den Bosch and Ode Sang, 2017). One of the SDG's goal (Target 11.7) is to provide (by 2030) universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities. The World Health Organization recommends providing each child with access to healthy and safe environments by 2020, a setting of daily life in which they can walk and cycle to kindergartens or schools, as well as to green spaces in which they can play and be physically active (WHO European Region, 2016: 1). The OECD Green Growth Indicator agrees on a standard of 14 m^2 of green space per inhabitant. The European Environment Agency requires a green park available at 500 meters walking distance (Mougiakou & Photis, 2014).[9]

Cultural ecosystem services are only irregularly considered in the evaluation of green infrastructures. However, green areas resisting to urbanization have often been conserved for their heritage value, the sense of place and identity they offer to their city and region, as explain Meltem Erdem Kaya*, İmge Akçakaya Waite, Başak Demireş Özkul, 2022 in the present Iglus Quarterly. O'Brien et al. (2017), when evaluating the social distribution of access to and use of urban forests, consider a wide range of benefits, including knowledge, participation, self-esteem, and confidence. They note that access is not just a matter of physical availability, but is also related to legal, ownership and other use rights. Barriers to access may indeed not only be physical, but also social, and for example, be due to lack of information and visibility of UGI or to cultural norms, a perceived lack of safety and confidence associated with green areas and open public spaces.

The important question of social justice shows that there is no objective, politically neutral way of defining what is a "protected area" or a green- or ecological infrastructure, as little as there is a scientifically objective way to decide which ecosystem services to provide where and for whom as a priority. Hence, it is better to recognize with Ernstsons that: *"Resilience is the capacity of a social–ecological system to sustain a certain set of benefits from biophysical processes, in face of uncertainty and change, for a certain set of humans"* (2013, p 14). Thus, to define who are the stakeholders remains a key question; with it comes the question about how and for whom to facilitate participation by minimizing inequitable power relations. Such practices are experienced by the Foundation Greening of Detroit, which states that: *"our mission focuses on improving the quality of life for and with De-*

9 Another standard - effective for communication - is *The 3-30-300 rule : 3 trees from every home, 30% tree canopy in every neighborhood, and 300 meters from the nearest park or green space*. Cecil Konijnendijk van den Bosch. https://nbsi.eu/wp-content/uploads/2021/12/NBSI-3-30-300-Program.pdf

troit residents, by increasing Detroit's urban forest and providing adult and youth workforce training combining the green with the blue infrastructures". Fai Foen, Director of Green Infrastructure at Greening of Detroit (IGLUS module, Jan 24, 2022) presents examples maximizing job opportunities for young unemployed youth, who work close to home, in nurseries, in community plant-ing and tending the trees, as well as in large scale re-mediation projects (infrastructure for stormwater man-agement) and in dendro-remediation, whereby planted trees absorb pollutants from contaminated soils.

An example of GI in Geneva: learning from prac-tices

The partner organizations of the canton of Geneva, the botanical garden of Geneva and the University of applied sciences of Western Switzerland have defined the cantons "ecological infrastructure" in the following terms: *"Ecological infrastructure designates all the reser-voirs of biodiversity – the most hospitable sites for a large number of animal and plant species – and the biological corridors that connect these places and thus ensure their vi-tality. It is a network of life which must guarantee the pro-tection of biodiversity over the long term, and therefore the ecological functions which make it possible to maintain a nature capable of adapting to climate and societal changes and thus of continuing to offer its benefits (also called eco-system services) to human societies."*

Honeck et al. (2020) explain how the GI for the canton of Geneva has been assessed, based upon an ecological and geographical analysis with multiple layers of data, informing *Species composition* (900 species of fauna and flora, with their spatial distribution), *Habitats* (organ-ized in over 80 categories), landscape *Structure* (habitats' fragmentation and connectivity monitored for some umbrella species – red deer, hare, toad) and five *ecosystem services* (pollination, carbon sequestration, water quality regulation, erosion control, regulation of microclimate and quality of air according to foliage).

The map of the green infrastruct surface (shaped in an hexagon) of Geneva, with a spatial resolution of 25 m^2, assigns each hexagon a value between 1 (low quality of biodiversity) and 100 (very good quality). The areas of highest ecological quality are forests, wetlands, and along waterways.[10]

A proportion of 30% of a total land's territory forming a high biological quality network is considered as a minimal condition for the green or ecological infrastructure to be functional and to be able to provide the ecosystem services necessary for society (set percentage based on the Aichi agreement of the Convention on Biological Diversity). However, the effective dimensions, i.e., the scale of a territory for which this proportion is effective for biodiversity, remains relative. Currently, the portion of a territory considered of sufficient quality in the canton of Geneva is 20.5% of its total surface: 10% of the cantonal territory benefits from appropriate management and sufficient protection in order to ensure its functionality and sustainability as a reservoir of biodiversity, and another 10.5% of the territory fulfills a biological corridor function.

The UGI map is meant to guide Geneva's land use planning strategies ; it helps to protect existing high biodiversity areas – avoiding urbanization and intensive agriculture in these geo-localized sensitive areas -- and it helps to situate where to restore the quality of land or water ecosystems in order to augment both the surface and the quality of the overall UGI network. This means for the canton of Geneva - if it wants to reach a 30% of its land surface to be of high quality (graded between 70 and 100)- to increase the ecological quality for 10% of its territory: aiming at an additional 7% of the canton's land surface for biological reservoirs and 3% for biological corridors. This GI map is in the process of being extended to the metropolitan region of the Greater Geneva, transboundary to France and Switzerland , including its urban, periurban and rural areas (Grand Genève).

The map will also be connected to a national wide

10 A GIS tool showing the green infrastructure - accessible to the public, used for urban and land use planning at cantonal and municipal levels, https://map.sitg.ch/app/?mapresources=NATURE.

Green infrastructure in the process of being developed through Switzerland with a methodology inspired by the Geneva GI. The GI across all territorial scales should orient decision making and planning where conserving and growing trees or, for instance, where to restore wetlands integrated in the urban fabric as well as in the farmed and forested land around cities.

Another EU-Swiss co funded Interreg project working on the urban edges of the transboundary Greater Geneva has shown that to attend the ecological quality of urban edges across urban landscapes (within and around the built tissue of agglomerations) will maximize the ecosystem services provided by the UGI, reducing heat island effects, cleaning air, infiltrating water, stocking carbon, providing fresh food, outdoor recreation and nature experience and other cultural services (Bailly et al, 2020). Adopting a green infrastructure network approach for biodiversity is also attractive for pedestrian and soft mobility infrastructure.

Recognizing the UGI in land use planning requires a cross-sectoral governance. Indeed, it is according to the UGI that any transportation, housing, and energy infrastructure should be adapted, minimized and if necessary compensated for locally or in the region. The UGI will also orient the plan to increase Geneva's canopy from 23% to 30%, it will contribute to the implementation of the Climate Plan for both reducing emissions and adapting to CC; It will help prioritize where urban areas need to be unsealed as a contribution to reducing heat island effects and the risk of flooding, but also where to densify in order to halt further landscape and habitat fragmentation and where to improve the dark infrastructure (Haaland & Konijnendijk, 2015).

Challenges for integrating GI in the governance of urban systems

To promote the assessment, the monitoring, the conservation and the reinforcement of the green infrastructure at the regional scale of citylands including the built and the non-built urban, peri-urban and rural landscape (Per Berg, et al. 2013) requires geographic information as well as ecological field research and planning at various administrative levels (Monteiro et al. 2020, Zuniga-Teran et al. 2020). If the analysis of UGI at met-ropolitan scale involves scientific studies it also requires the involvement of the public service enterprises working on energy, providing electricity and transportation. For implementing the UGI, informing, sensitizing and turning thoughts into actions, municipalities with the participation of citizen's associations are key players (Hansen et al. 2018). In the end, it is at local levels, and up to landowners, inhabitants and various infrastruc-tures' users to change their representations of a desirable life, their habits and even their perceptions, for instance of light as an indicator of comfort and security, of soil perceived as dirt, of wild plants considered as weeds and insects as pests.

GI research, communication and multi-actor processes need to consider human and other species' health as a common good. This means that the state cannot alone address the challenges, civil society, and private actors need to be actively involved too. But modern institu-tions (regulatory, policy and economic institutions) are not well equipped for a robust governance of common goods, especially when working with diverse user groups and resources. Urban green infrastructure governance entails multistakeholder based decision-making. The self-organizing capacity of users in large metropolitan areas needs to be reinforced. The cul-tural values of UGI are a powerful motivation for people to engage in local natural resource management (Fin-ger-Stich 2005). The cultural values have indeed not enough been recognized in the ecosystem service approach of the 90s, focusing mostly on their economic value.

The governance and management of UGI varies be-tween cities, but in general the cities tend to promote in-terdisciplinary, participative and cross-sectoral processes that augment the social capabilities required for an UGI effective implementation (Lawrence et al. 2013).

All factors affecting the ecological functionality of ecosystems need to be considered, round the clock, the seasons and across all the territory's diverse natural or semi-natural habitats and built neighborhoods. The ecological transition of cities should not only aim at no CO_2 emission but at no further artificialization of soils. This means, if more housing is needed parking lots or airports have to be unsealed to make place to riverbeds, to augment the urban forest's canopy, to offer urban parks for recreation, or urban farms, according to local contexts and people's interest and capacities (Ciftci, 2019). Indeed, urban green infrastructures provide many services to the city, but caring for it, means also reconnecting the urban people with nature, with the cityland's trees, water, soil and wildlife.

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In Consideration of the Urban Tree

Naomi Zürcher, Arboraegis

Based on both a book chapter entitled *In Consideration of the Tree ….* as well as a monograph entitled *Connecting Trees with People…*, Naomi Zürcher, Urban Forester/ Consulting Arborist/ i-Tree team affiliate member, provided IGLUS students with a soup to nuts recipe for growing large canopy urban trees well into maturity, including consideration of its closest associate – the soil organism, based on ecological design principals.

The focus of an ecological design approach to spatial development is to minimize environmentally destructive impacts in planning and designing the built environment. To support this intent and the integrity of the urban ecosystem, we must give much greater consideration to the structure and function of an indispensable part of that ecosystem – our trees - and the impact our built environment imposes on them and their ability to provide the ecosystem services' benefits we increasingly depend on.

Almost all trees planted in our urban centers originate in a forest somewhere in the world. Their tolerance of urban conditions has brought them to our urban environment but they remain forest trees and, regardless of where they are planted – forest, open landscape or city streets - they still retain their forest genetics. Their ability to adapt to environmental conditions is part of their self-management strategies but that capacity must be enabled. It is therefore essential that we incorporate an understanding of Forest Ecosystem - what makes a tree a tree – genetically and structurally, and how that forest tree manages itself.

Forest: a soil-based evolving, adaptive ecosystem – a community of trees and all their associates - related flora, funga, fauna and, most importantly, soil, supporting a mycorrhizal network and a microbial and invertebrate community, which, in combination, provides the air, water and nutrients all associates in the Forest community depend on, either directly or indirectly. Environmental conditions such as temperature, the soil's pH and the availability of light and water will determine what species are growing and where. Although consisting of different tree species, space above ground is shared in competition while space below ground is shared in community. Trees are social. they are collaborators. They have evolved to depend on a communal rooting landscape of connective tissue, sometimes referred to as the wood wide web, providing inter-species communication that enhances self-management processes. Photosynthesis, both in leaves and woody tissue, delivers the fuel that propels the entire system's processes. A tree's root system begins at the trunk > root transition zone with the development of at least one first order root in each of the four cardinal directions – the root system's perennial framework which branches out horizontally into surrounding soil, decreasing their diameter as they grow into fine, non-woody roots. Almost all of this extension activity occurs within the top meter of soil with fibrous roots in the uppermost portion and even into the decomposing forest floor litter, extending a minimum of 2.5 - 3 times the width of the crown. Forest soil is always covered by related flora, leaf litter or other organic Forest detritus - a constant recycling of organic resources. A healthy, diverse soil ecosystem is the foundation for forest health and likewise for the urban tree to enable the ecosystem services so essential to urban well-being.

Planning and managing that accommodates urban trees' needs begins with knowing exactly what exists within the Urban Forest. This ongoing assessment requires an urban tree inventory that analyses the existing resource. Complementing such inventory with i-Tree Eco to quantify the ecosystem services the existing tree resource is delivering (https://www.itreetools.org/about) helps Urban Foresters or Arborists as well as citizen participants to inform ecologically sound urban system governance.

Bluegreen: a management perspective on urban blue and green infrastructures

Matthias Finger, Professor, Istanbul Technical University, Istanbul, Turkey

Urban water – supply and sanitation – is typically looked at as an infrastructure that is unconnected to the other urban infrastructures, such as the energy, the transport and the communications infrastructures. Regrettably, it is also not connected to the urban green infrastructures and to urban space more generally. It is basically looked at as being a closed circuit, just like electricity or gas. However, water is part of the water cycle: it is pumped from somewhere and goes somewhere and therefore connected to the larger river basin. This is actually already well known but not really integrated yet in the way one looks at urban water management. With climate change the problem of stormwater is arising: this water can often not be absorbed by the current sanitation infrastructures, creates urban flooding, often with loads of contaminants from the streets, sewage, and runoff from the roofs and ends up in the cities' green infrastructures and affects their quality and their sustainability, with negative consequences for biodiversity as well as for residents. Therefore, additional urban blue infrastructures will have to be created to absorb and clean such stormwater, but one must also find more natural ways to absorb, to store and to filtrate it. In other words, there is increasingly a very close interrelationship of the blue with the green, as well as with all other urban infrastructures.

In this article I would therefore like to outline a more systemic view of urban water. I will proceed as follows: in a first section I will highlight the current view of urban water and its management. I will then show how, as a second step, this relates to the water cycle and river basin management. In a third step, I will show how this is increasingly linked to the green infrastructures and their ecosystems services. Finally, I will discuss a more holistic approach which looks at the entire urban infrastructure system, blue and green included, thus raising the question of infrastructure system governance.

The engineering view on urban water

Like with all the urban infrastructures, there is a silo-view when it comes to urban water, whereby both water distribution and sanitation are looked at – sometimes even separately – as closed purely technical systems. The focus here is on the water well (sometimes an open source), the transportation from that well to some cleaning station as well as the distribution pipes. Similarly, sanitation focuses on the collection of wastewater from the households, the industrial plants and the streets (runoff), the transportation of such wastewater to some treatment station, from where it is discharged into a river or artificial lake. And there is indeed enough to do here and technical challenges are getting bigger by the day.

For example, groundwater tables are falling or drying up. Or with urbanization the space needed for underground collection of the water is getting scarcer. Also, groundwater is getting more polluted, especially with new micropollutants for which the water cleaning plants are not (yet) equipped or the corresponding technology does not yet exist. Or the simple fact that cities are growing and need more water for which new cleaning stations have to be built, which in turn need appropriate location and financing. Then there is the whole issue of water leakage, an old phenomenon, but which gets worse over time: once leakage levels reach 30% or more, it becomes imperative to put in new pipes, something that may anyway be needed because of the growing demand. All this needs energy, mostly electricity, which increases the costs of water distribution. But the potential problems do not end once water has reached the house, the apartment or the industrial plant: there are water losses inside the buildings, not to mention the careless waste of water. While distribution companies do not necessarily have an incentive (yet) to push consumers to save water, public authorities and society at large have and water waste will therefore increasingly become an issue as well.

And there are the exact same challenges when it comes to the downstream part of the urban water cycle: one needs to make sure that all the sources of wastewater are connected to the sanitation grid; and there are many, especially many dispersed ones. The biggest challenge here are not the households or the industrial plants, not even the leakages, as the wastewater pipes are usually less old having been put in much later. The biggest challenge here are the dispersed sources of polluted water, mainly from the roads with all their pollutants. Also, wastewater treatment plants are a big challenge, as they need space and also ever more sophisticated technologies to clean the water to the point that it can be discharged safely into some river or simply released into the ground. All this of course consumes energy again, even though at the end of the pipe sludge from the wastewater can be used to generate energy (see below last section).

This very engineering view of things has been the focus and the task of urban water managers. And much technological progress has been made here in the past and will have to be continued into the future, as the challenges will only get bigger. But this engineering – and increasingly economic and financial – look at urban water distribution and sanitation will not be sufficient going forward.

The economic externalities' view or the water cycle

With increasing water scarcity and pollution, water can no longer be approached as a purely engineering issue of pumping, cleaning, transporting, collecting and disposing. One now also has to consider the resource. And when speaking of the resource, one inevitably has to consider the water cycle and its relevant ecological unit, i.e., the watershed or the river basin. Yet, the resource, even when embedded in the river basis, is totally intertwined with earth system dynamics and changes.

Water management within a river basin is already well known, especially in France and in Europe, where a Water Framework Directive was created in the year 2000. The key element of so-called river basin management is the watershed as the relevant geographical unit. This is a unit that is ecological and not political in nature. Furthermore, river basin management has to consider the fact that water flows downhill, meaning that one has to distinguish between upstream and downstream users of water. In other words, the more water is consumed upstream, the less water will be available downstream. Furthermore, the more polluted the water that is released upstream, the bigger the efforts for cleaning it downstream. Ideally, a river basin agency is set up in order to ensure the proper governance of both the quantity and the quality of the water in a given river basin. And recommended to be, again, the appropriate management tool is a water (and wastewater) pricing mechanism. In other words, there is a price for abstracting the water upstream and a price for discharging the water downstream. While the upstream price is linked to water quantity, the downstream price is linked to water quality. A so-called river basin agency makes sure that the respective prices are set correctly, that the points of water abstraction are identified, that the abstracted water is measured both in quantity and in quality, that the points of discharge are identified and that water quality is measured at the point of discharge. If the quality of the water discharged is lower than the quality of the water abstracted, the point of discharge will have to pay a regulated amount to the river basin agency, which will then transfer the money to the downstream water utility in order to pay for its cleaning costs.

As a next step, river basin management and urban water provision and sewerage have to be integrated. This is typically again reduced to a pricing mechanism type of economic solution. In other words, water consumers – both households and industrial consumers – should in principle pay for the water resources they consume, while wastewater producers (again households and industrial plants) will have to pay for the quality of the water they release back not the watershed (polluter pays principle). This is of course not done on an individual (households and firms) basis, but typically administered by the water and wastewater utilities. In this way, the water externalities are integrated into the water price. And this is often just one single price, as the water discharge fees are generally integrated into the water consumption tariff so as to avoid illegal discharging.

The (economic) ecosystems' services view

But not all points of water discharging can be controlled and therefore water discharging will only be imperfectly priced. And to a certain extent this is even true for water sourcing. Indeed, households and firms are often abstracting water directly from the watershed, thus bypassing the local water utility. This is not untypical and worldwide quite usual for irrigation purposes in developing countries. As said above, water pollution can stem from particular in urban contexts, from sources, both households and factories. But oftentimes, pollution simply comes from runoff from roofs, buildings and streets and no particular point of discharge can be identified and even less so obliged to pay. Typically, the costs for cleaning the non-point source water will be divided by all the water consumers in a given area and therefore nevertheless be paid.

But, at this point we can and have to establish the link between water management and green infrastructures. As demonstrated by Andréa Finger-Stich in her article, green infrastructures provide numerous ecosystem services, among which the absorption of air pollution and the cleaning of runoff water. In other words, green infrastructures have to be considered as an integral part of water management, meaning that ecosystems' services stemming from green infrastructures should be included in the costing and pricing of water.

The same consideration also applies the other way round: indeed, it is likely that the water quantity and quality strongly relate to the city's green infrastructures. The less available groundwater there is in a given urbanized area and the more this water is polluted, the less the quality of the ecosystems' services of the green infrastructures will be, and more generally the less green infrastructures are possible.

In short, the ecosystems' services approach will oblige us to consider and manage blue and green infrastructures jointly in the future, i.e., in a systemic manner. And this will of course have to be reflected institutionally.

The industrial ecosystem's view

But there are not only blue and green infrastructures in a city, in need of being managed together. There are also grey (transport) and brown (buildings) infrastructures, plus there is energy and the related energy infrastructures. All these – together with the telecommunications infrastructures – constitute in fact one single urban infrastructure system and should be considered and managed as such. This is the so-called *IGLUS Way*.

But before doing so, let us explore some further links. Let us start with the link between the blue (water and wastewater) and the brown and grey infrastructures: Buildings consume and discharge water and both need to be fully integrated into water management and the water cycle. And of course, cleaning and transporting water consumes energy. Consequently, a more efficient water management notably thanks to digitalization will reduce both energy and water consumption. Grey infrastructures – and any city is composed of approximately 25% of transport infrastructures including roads, rail, metro and tram tracks, as well as lots of parking space for cars – are prone to runoff, i.e., rainwater charged with pollutants. All this ends in the sewage system and will hopefully be cleaned (to a certain extent) before being discharged into a watershed. The situation is of course much worse in the case of storm water which oftentimes cannot be absorbed by the sewage systems, thus carrying many more pollutants and thus not passing through a wastewater treatment plant. Green infrastructures can of course significantly alleviate the problem, notably by serving not only as an absorbant of runoff and stormwater, but also as a depolluting filter. And all this can of course be linked to energy, as natural green infrastructures are much less energy-consuming pollution filters and absorbers.

All these links could of course be detailed and developed much further, considering the cooling effect of green infrastructure, contributing to save on some of the city's water demand.. Yet the picture and the message is clear: all urban infrastructures are closely linked with each other and only a resolutely systemic approach will be able to reap the benefits of the many synergies that are possible, yet not (yet) really exploited. Digitalization is of course the main tool for establishing these links and thus for making cities smarter, i.e., more efficient, more sustainable and more resilient. However digitalization without active exchanges between the managers of the various infrastructures and their respective administrative sectors will not be effective at improving the situation. Digitalization needs also to give more voice to the end users of both ecosystem's and other than green infrastructures' services, and to their demand for healthier living environments. The quality of drinking water and green infrastructure are indeed essential indicators of attractive and healthy urban systems.

Investigating the multi-dimensional management of transforming megacity landscapes through the Golden Horn, Istanbul

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Introduction: Complexities of managing green infrastructure transformations

Cities around the world have been subject to massive transformation processes, with a broad accompanying impact on society and the environment. While small cities have experienced more dramatic change, megacities have usually become the central driving force affecting all connected settlement systems and associated landscapes, both operational and natural. Because of their complex structure, contemporary megacities often share similar characteristics and associated problems in different geographical contexts, particularly in the Global South.

In contrast with monocentric settlements, polycentric megacities are structured with densely populated districts tightly connected by infrastructure systems in which the flow of people, material, information, and energy has become the main agent shaping physical space and social interaction (Wall, 1999). Such cities may also play a leading role in addressing climate change and its cumulative environmental and social effects, a serious issue that demands attention at scales both local and global. Professionals are presently attempting to find workable methods of coping with the challenging conditions of climate change and mitigating its negative environmental impacts through the introduction of novel strategies to urban planning and design (Satterthwaite, 2008; Yazdanfar & Sharma, 2015). In addition to ecology-based approaches and methodologies developed for physical spaces, the governance of large urban systems has become a central topic in addressing overarching issues to create well-functioning socio-ecological systems.

Following upon current trends in metropolitan areas, this paper introduces an interdisciplinary study that focuses on a particular urban corridor associated with one of the largest water systems of Istanbul: the Alibey river basin and its estuary, the famed Golden Horn. The management of this dense corridor, with its peculiar historical and socio-economic characteristics, revolves around three key topics: green infrastructure, urban development, and industrial and residential transformation. As part of a Swiss-Turkish collaboration, the study area was closely examined during an international executive master program field trip and workshop attended by 11 participants from around the world holding managerial positions in the governance of various urban affairs in their home cities. Based on expert opinions derived from the field trips, this paper argues that varying urban and landscape planning efforts should be coordinated to address the green and blue infrastructure of the river basin in its entirety. Such an approach can serve as a critical example in any discussion of superposed ideas intending to create a holis-

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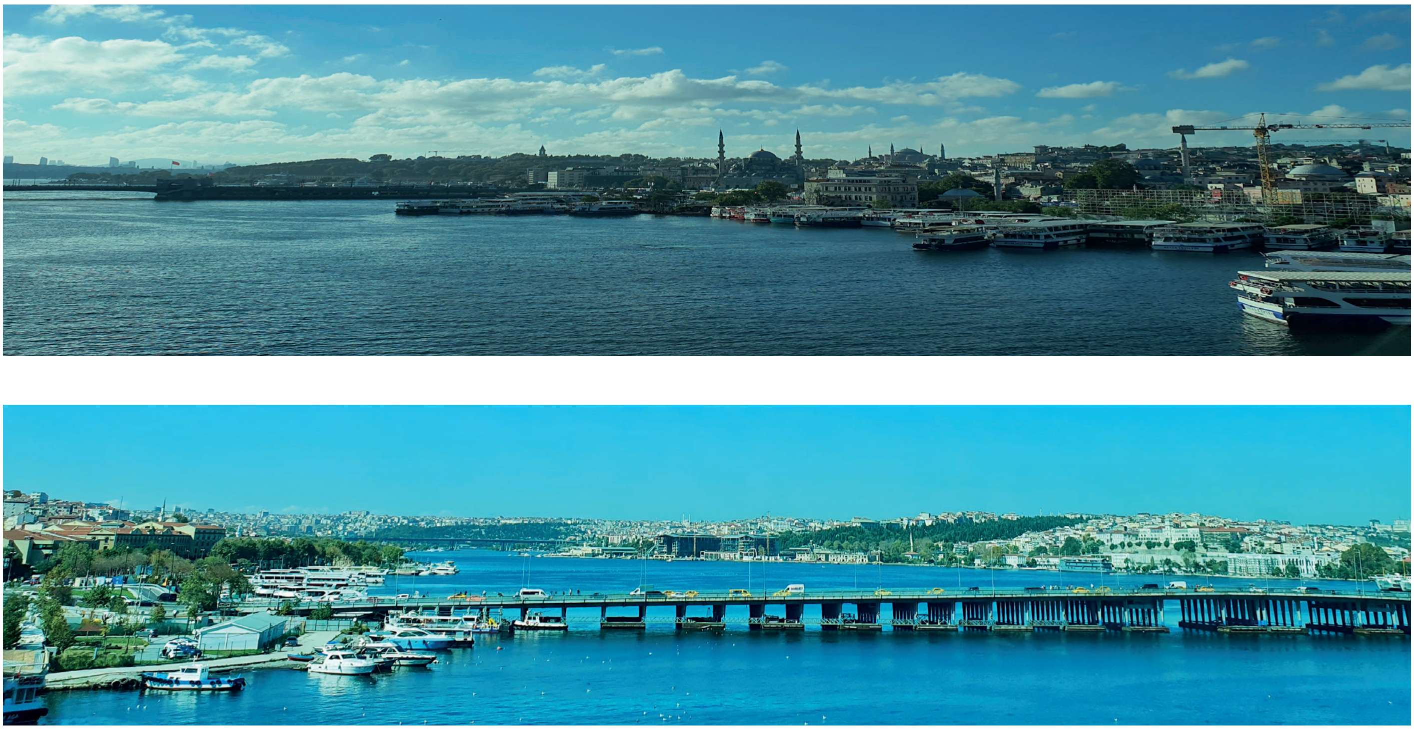

Figure 1. The Golden Horn (Photographs by Başak Demireş Özkul, 2022)

tic perspective in the management and redevelopment of fragile environments in existing and emerging megacities around the world.

The Golden Horn: A dramatic landscape

The megacity of Istanbul has been experiencing rapid spatial and social transformation since the beginning of the 20th century. Housing more than 16 million residents, the city is currently expanding into its hinterlands and natural reserve areas, which comprise a critical feature of the city. Istanbul is situated on a fluvial topography replete with water basins, stream systems, and wetlands. Its location at the junction of two continents and the resulting transitional climatic conditions provide suitable ground for the emergence of a rich ecosystem structure. Despite its fragile natural environment, however, the city has been to the site of multiple mega projects, whose large infrastructure overlaps with these delicate ecosystems. under the dual pressures of population growth and environmental degradation, Istanbul has always had to face issues concerning green and blue infrastructure and its relationship with the urban fabric.

The study area, Golden Horn, a water corridor of Istanbul of both historical and natural significance, lies in the center of the historic core of the city, expanding along the northwest-southeast axis (Figure 1). It is a horn-shaped body of water 7.5 km long and ranging in width from 200 to 900 m, with a total area of roughly 2500 ha. (Coleman et al., 2009). Its deepest point is 42m at the Galata Bridge section, with the depth of the river decreasing as it is removed from its source, with island formations appearing along its course. The surrounding topography is stark, with the highest point at 140 m. in the eastern hills and relatively level ground extending 150 m out from both sides of the shoreline. The western side contains smooth hills 40-50 m. in height. The small valleys surrounding the river have been occupied by dense neighborhoods, a considerable portion of which are stocked with decades-old illegal housing developments. At the same time, the area has been subject to considerable efforts towards gentrification through housing transformation (Soytemel, 2015).

Though the geography of the Golden Horn has made it a natural port since the founding of the city (Kızıltan, 2014), the estuary has often had a precarious relationship with its surrounding neighborhoods. Records show that after the conquest of Constantinople by Mehmet II in 1453, the husbandry prevalent along the coasts of the estuary was prohibited and the banks planted with trees to limit the amount of pollution and alluvial flow into the Golden Horn (İlyasoglu and Soytemel, 2006). The Haliç shipyard, since 15th century, was a center of industrial innovation and engineering in the Ottoman Empire from the 15th century until its dissolution (Baytın et al., 2003).

The 18th century was the estuary's golden age, with ports, mansions, and summer palaces fostering an Ottoman–Islamic neighborhood identity constructed along its banks (Baytın et al., 2003). Changes in maritime trade after the 19th century diminished the economic role of the waterway, and factories began to replace the port functions. These manufacturing plants, slaughterhouses, and shipyards elevated pollution levels and threatened the viability of the estuary. The neighborhoods on the shoreline also contributed to filling up the waterway with sediment through the discharge of wastewater and sewage. This area beyond the city walls became inhospitable, populated with rudimentary production facilities and storage shacks (İlyasoglu and Soytemel, 2006).

After the establishment of the Turkish Republic, the corridor was transformed into the new industrial zone of the city, following in the footsteps of Henry Prost's plan. In 1985 its banks housed over 700 industrial sites and 2000 businesses. In step with industrialization, illegal housing and a rising population along this natural corridor led to a high degree of environmental pollution (Coleman et al., 2009). In 1986, Bedrettin Dalan, the first Mayor of the Greater Istanbul Municipality (GIM) from 1984 to 1989, oversaw the Golden Horn Waterfront Revitalization Project (Keleş, 2003). This project, funded by international finance and development agencies, centered around the Istanbul Metropolitan Master Plan drawn up in 1980, which focused on relocating industrial facilities to the periphery of the city and giving the Golden Horn a new identity through the preservation of historical buildings and the beautification of the shoreline via a network of parks and supporting facilities. These improvements and de-industrialization initiatives were seen as a way of creating a new identity for the aspiring global city and providing it with a "Cultural Valley."

The blue-green-grey infrastructure

An estuary with a thriving fishery until the late 20th century the Golden Horn is also a natural corridor with an important role in terms of connectivity as a linear landscape element connecting the Bosphorus strait to the Alibey and Kağıthane streams and the northern forest of Istanbul. Alibey dam, the source of the Alibey Stream, serves as a water reservoir and provides potable water to the city; plantation areas in the vicinity of the dam link it to the northern forest. Most of the green areas along the Golden Horn, most of which are utilized as public parks, are fragmented by various infrastructures. These green areas reflect poor design solutions with a limited ecological capacity to respond to current environmental trends arising alongside climate change, thus failing to provide a resilient river landscape. Amplifying the effects of such land use character along the Golden Horn are the disposal of untreated sewage and waste resulting from the rapid growth of the city, the deposition of materials from surrounding hills, and silting caused by the Alibey and Kağıthane streams, which have filled the waterway and worsened its water quality over the past four decades. Consequently, the Golden Horn has become home to the most alarming environmental problems of the city and to the object of large-scale reclamation and restoration projects (Berilgen et al., 1999; Karakaş, 2011; Coleman et al., 2009).

Since the early 1950's, the Golden Horn and its two important tributary, the Alibey and Kağıthane streams have been subject to reclamation works as well. Both streams have been channelized in order to control overflow; the Alibey stream and the surrounding area are highly built up and sealed with asphalt and concrete, lacking any ecological structure. On the other hand, the Kağıthane stream has linear green areas that provide a limited capacity to control overflow and ecological diversity and integrity. The first phase of the reclamation work of the Golden Horn included cutting the pathway of contamination through the closure of 659 factories and 2020 small craftsman and by transferring the polluted water to the treatment centers. The second phase involved the removal of mud sediments by dredging the bottom of the Golden Horn and the oxygenation of the water through the aeration. The third step called for the restoration of the historical and cultural assets associated with the landscape projects. The Golden Horn Environmental Protection Project was prepared by the Istanbul Metropolitan Municipality (IMM) and the Istanbul Water and Sewage Directorate (ISKI) (Karakaş, 2011). As a result of long-term remedial actions the waterway has now been transformed into an actively used river space under maintained control. Today, the estuary's significance lies not just in its presence as a green and blue corridor, but also as a cultural one. Possessing a diverse land use pattern, the corridor intersects with infrastructure such as highways and bridges over the surface. The waterway also connects urban elements such as historical buildings, churches, mosques, universities, cultural centers, and neighborhoods, all of which constitute the grey infrastructure of the region.

Addressing the so-called grey infrastructure of the Golden Horn necessitates an understanding of the redevelopment efforts practiced in this area in terms of project timeline and governance structure. The highlights of this timeline include the emergence in the 1950s of industrial plants along the Golden Horn's shores persisting into the 1970s and early 1980s, the clearance of these plants and reconstruction of the waterfront, including post-industrial regeneration projects in the 1980s, the international conservation initiatives in the area's historic neighborhoods in the 2000s, and the impacts of the resulting gentrification in the 2010s (Günay and Dökmeci, 2012; Enlil, 2011; Bezmez, 2008; Baycan and Kundak, 2003). More specifically, the following redevelopment projects can be referenced in the narrative of dramatic interventions:

The Istanbul Metropolitan Master Plan of 1980;

The Golden Horn Waterfront Revitalization Project led by the IMM between 1984-1989;

Estuary cleaning and remediation projects starting in 1994 (also known collectively as the Golden Horn Culture Valley Project) led by the IMM's Water and Sewage works company (ISKI) and supported by the World Bank;

The program to rehabilitate the Fener and Balat Districts led jointly by the European Union and the Fatih District Municipality starting in 2003;

The Istanbul Environmental Master Plan of 2006 and the Istanbul Strategic Plan for 2010-2014;

Regeneration projects for the historic shipyards of Haliç, Camialtı, and Taşkızak led by the IMM starting in 2011.

Though the Golden Horn was a popular tourist attraction and a region with affluent neighborhoods overlooking the estuary until the 1970s, rapid industrial development and the resulting mass labor migration flow of the 1970s and 1980s caused a dramatic shift in housing patterns: the residential areas lost their prestige, and the wealthier classes moved out. Squatter housing (*gecekondus*) became the dominant type of settlement in the vicinity of the waterfront industrial site. Meanwhile, discharge from such residences and factories resulted in water pollution. In the mid-1990s and 2000s, the aforementioned major projects to reclaim the Golden Horn initiated an organized governance movement to rehabilitate the city's *gecekondus*, starting with the north-west of the historic peninsula and including the Golden Horn area. An expected major earthquake in Istanbul informed the government's discourse on the transformation of the city, which resulted in Alibeyköy's declaration as an earthquake-risk area in 2016. This development was accompanied by massive housing redevelopment projects in the Golden Horn valley, including the ongoing 5th Levent Project that will replace around 500 mostly low-income *gecekondus* with approximately 4,200 luxury housing units in a 51.6-hectare area right next to the Alibey river. The formal actor structure for the decision-making of these housing redevelopment projects in terms of its main players include the central government's Mass Housing Administration (TOKI), the IMM, and the major private development companies.

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Concluding notes

Investigation and discussion of the case of the Golden Horn has made it clear that as part of a larger urban system, the governance of green and blue infrastructure requires both multi-disciplinary and interdisciplinary expert studies and collaboration with different stakeholders to create a holistic view of critical and dynamic landscapes. Just as the principles of green infrastructure concept suggest an integrated lens to urban landscape, ecological, cultural and economic goals should be balanced with the integration of innovative technologies and ecologically sound planning approaches. In particular, multi-level and inclusive governance strategies become critical for metropolitan cities like Istanbul, which houses the elements of green, blue, and grey infrastructure in conjunction. In this sense, the Golden Horn exemplifies the multifaceted relations between economic, ecological, and social structures and provides for an understanding of how to manage this complex urban landscape.

For the last few years, there have been significant attempts in this direction: The IMM has developed a green infrastructure vision for the planning and design of urban green spaces in Istanbul. Instead of evaluating green areas just for their recreational value, this new vision underlines a framework to manage the green spaces with their ecological, social and cultural values in a holistic manner. The foundation of "green area management system" of the IMM is one of the concrete outcomes of this vision. On the other hand, the IMM tries to implement best practices for the planning and design of the Golden Horn. To that end, the IMM has organized a national planning and design competition for the entire Golden Horn shoreline to achieve the best proposals developed for this complex urban landscape. Today, those that were awarded top prizes are being implemented.

The Golden Horn is a complex and attractive environment surrounded by networks of transportation infrastructure and diverse land use patterns. The green and blue infrastructures become an underlying foundation in which diverse land use types are embedded. For the future projections, maintaining the relationship between the green-blue and grey infrastructure within sustainability framework will be an important goal for the IMM.

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Governing the critical landscape: The Golden Horn technical field trip of the IGLUS Istanbul module

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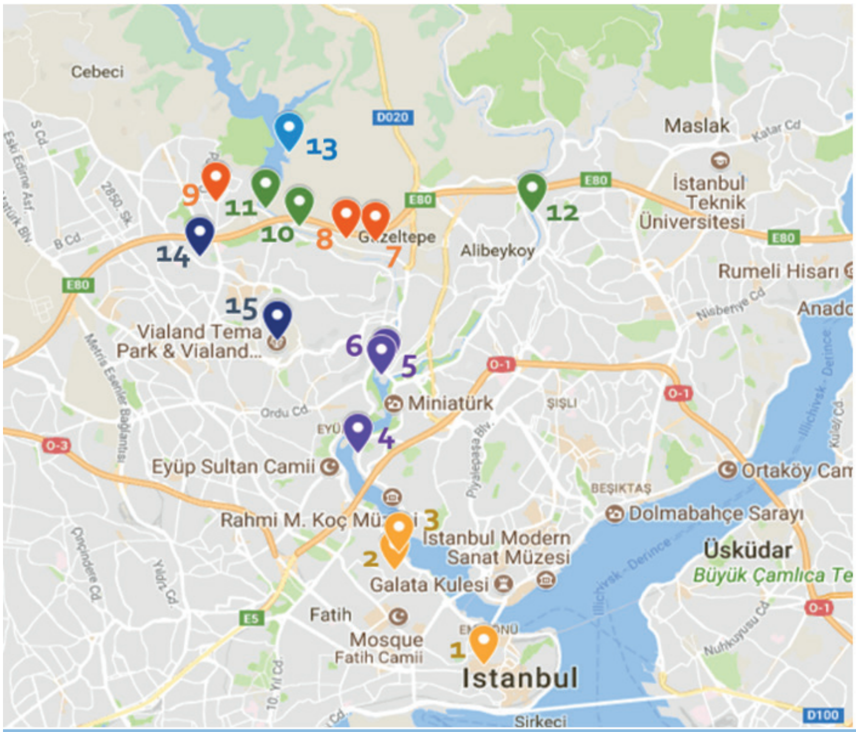
Managed by the École Polytechnique Fédérale de Lausanne (EPFL), the Executive Master Program of Innovative Governance of Large Urban Systems (IGLUS) includes modules that bring together program participants from around the world in select leading megacities across five continents (www.iglus.org). Since 2017, the Istanbul module has been conducted in collaboration with Istanbul Technical University's (ITU) Faculty of Architecture. This module focuses on the governance of transport, housing, and green and blue infrastructure of the city. The Golden Horn is among the main foci of the module's exploration of this infrastructure; the site visit involves a day-long field trip along the Golden Horn river and basin, with on-site lectures from ITU professors and appointed visits to the waterfront transformation sites and the Alibey River and Dam accompanied by local experts, all enriched by discussions steered by participants and the IGLUS Istanbul lecturers. The latest field trip was held in May 2022 as part of the IGLUS Istanbul module 2022, with the involvement of four ITU and EPFL professors of landscape architecture and urban planning, network infrastructures' management, and 11 module participants from Switzerland, Singapore, Russia, Venezuela, France, Serbia, Iraq, and Turkey. The field trip was followed by a half-day workshop at ITU.



Pin #	Topic / Activity
Along the Golden Horn	
1, 2, 3	Historic peninsula & the Golden Horn: history, location, transport
4	History of transformation of industry areas along the east shore
5	Museum tour: Museum of Energy
6	Campus tour: from power plant to university
Along the Alibey Stream	
	KİPTAŞ & TOKİ as main government actors of redevelopment in Istanbul
7, 8	5. Levent & Finanskent housing projects
9	*Gecekondu* (squatter) areas: Gazi Neighborhood and its vicinity
10	Municipal landscaping in Istanbul & IMM Istanbul Trees and Landscape Corp.
	Green infrastructure of Istanbul: general applications
11, 12	Alibeyköy & Kağıthane stream remediation projects
At the Alibey Dam and the "People's Park" of Gaziosmanpaşa	
13	Dams within Istanbul's green infrastructure
	Istanbul's water provision through scarcity
14, 15	More redevelopment projects in sight: TEM Avrupa, Vialand, etc.
	Discussion on the go: the Golden Horn as a case

The Golden Horn field trip itinerary and discussion topics as part of the IGLUS Istanbul Module 2022

The IGLUS Golden Horn field trip 2022 (Photograph by Marko Vrkljan)

The on-site lectures, case narratives from local experts, discussions, and observations of the field trip demonstrate that the Golden Horn is a remarkable case in the middle of a metropolitan city. Through its deep history and multi-layered cultural and ecological structure, this special waterway raised critical questions concerning how local and international urban governance bodies manage green and blue infrastructure, how to integrate green and grey infrastructure within a diverse functional setting, and how urban management does and should provide a collective platform to control, protect, and enhance this multilayered landscape.

During the Golden Horn field trip, the module participants examined in detail the impacts of the industrial and housing redevelopment projects on the natural conditions of the Golden Horn and its connected water system while observing real-time consequences of recent interventions on site. This perspective allowed for the examination of the Golden Horn as part of wider green system and in terms of both its potential to create a green infrastructure framework and the current problems related to its physical structure. The IMM's efforts to remediate the Golden Horn river using the latest contamination and remediation methods helped the participants discuss the implementation capability and timeliness of the municipality's agenda. The common stream reclamation trends based on concretizing stream beds adopted by the IMM's water infrastructure company ISKI contributed to the topic in a critical light, followed by a discussion of the measures to be replaced with current methods. The IMM's policies concerning green area planning and design were examined through the identification of the stakeholders in the management of urban green areas such as the latest "people's park" located in the Golden Horn and Alibey basin.

Urban Forests' Ecosystem Services in terms of evaluation of complex ecological processes

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In a changing climate and environmental structure, meeting human demands such as freshwater, food, clean air, and protection from natural disasters has become more crucial. This situation shows itself with the changed climate all over the world and the negative effects such as water scarcity, floods, extreme temperature, and extreme precipitation events. At this point, one of the aggravating factors is the change in land use and land cover.

In this perspective, İstanbul can be a good example in the context of being the most populated city in Turkey with more than 15 million people (TUIK, 2022) and having intense anthropogenic pressure on land use and land cover to meet the demands of large and this dense population. Consequently, the conversion of land use/cover has become irrepressible.

Within this context, previous studies conducted on different land use types in İstanbul showed that natural ecosystems, especially forest areas, have the highest potential for providing many ecosystem services (Uygur, 2016; Uygur Erdoğan, 2017) (Fig. 1). In these studies, it is mentioned that forested sub-watersheds had high relevant capacity whereas urbanized sub-watersheds had a high relevant capacity to provide water quality regulation services. In other words, it was determined that while forest areas improved the water quality, urban areas deteriorated the water quality (The color on the water quality score map shows the quality of water and the darkness of the red color means worsening the water quality (Fig. 1c)). Additionally, the same studies revealed that urbanized sub-watersheds had a lower relevant capacity compared to forested sub-watersheds to provide flood mitigation services. The amount of retained rainwater by different land use types with values varying between 0% - > 66% can explain this situation (Fig.1 d).

Fig.1a The location of study area

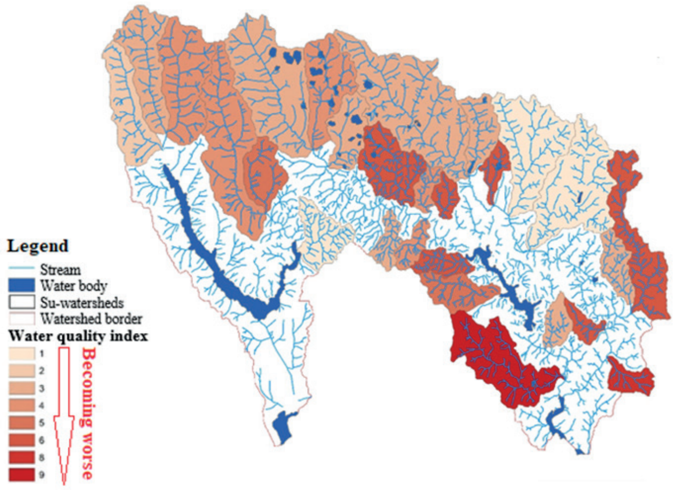

Fig. 1c The water quality index map

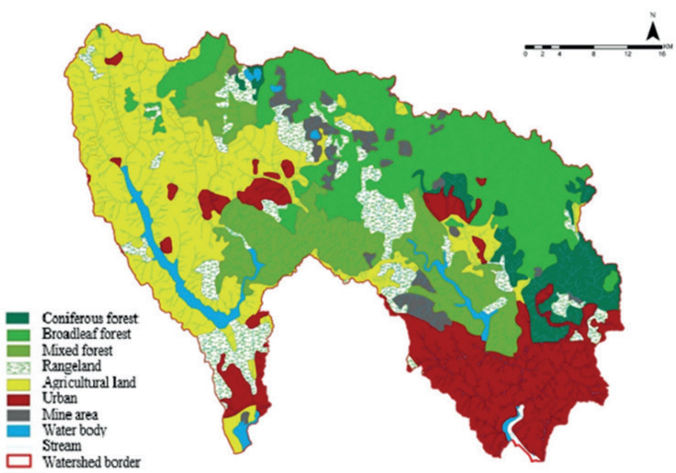

Fig. 1b The land use types in the study area

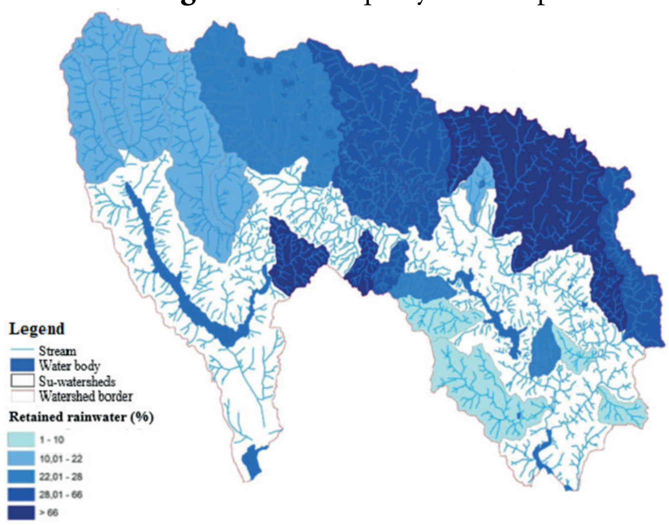

Fig. 1d The amount of retained rainwater by different land use types

This study shows that forests have vital ecosystem services such as naturally providing clean potable water, and preventing floods and torrents due to their important functions (water storage, shading effect, regulation of water flow, etc.) with some processes (evaporation, infiltration, transpiration, etc.) as a consequence of their unique structures (vegetation cover, soil structure, etc.). As an outcome of this, it's so obvious that if the natural ecosystems (especially forests or vegetation) have been damaged then the hydrological processes are damaged too.

In contrast to this, the Northern part of the watershed has undergone a land use change with the 3rd airport and the 3rd bridge connection roads named Northern Marmara Motorway (Fig. 2). This land use change has led to the loss of some ecosystems and the ecosystem services they provide, as well as the fragmentation of forest areas. It is also clear that this road network will increase the pressure on forests. The high loss in natural areas (e.g., forests, agricultural areas, green areas) and related ecological services will increase the vulnerability of the city to floods and climate change impacts.

Considering the negative outcomes of this situation, at least for the future, it needs to be understood that the structure of urban ecosystems needs to be improved in the presence of natural ecosystems, for the city to become more resilient.

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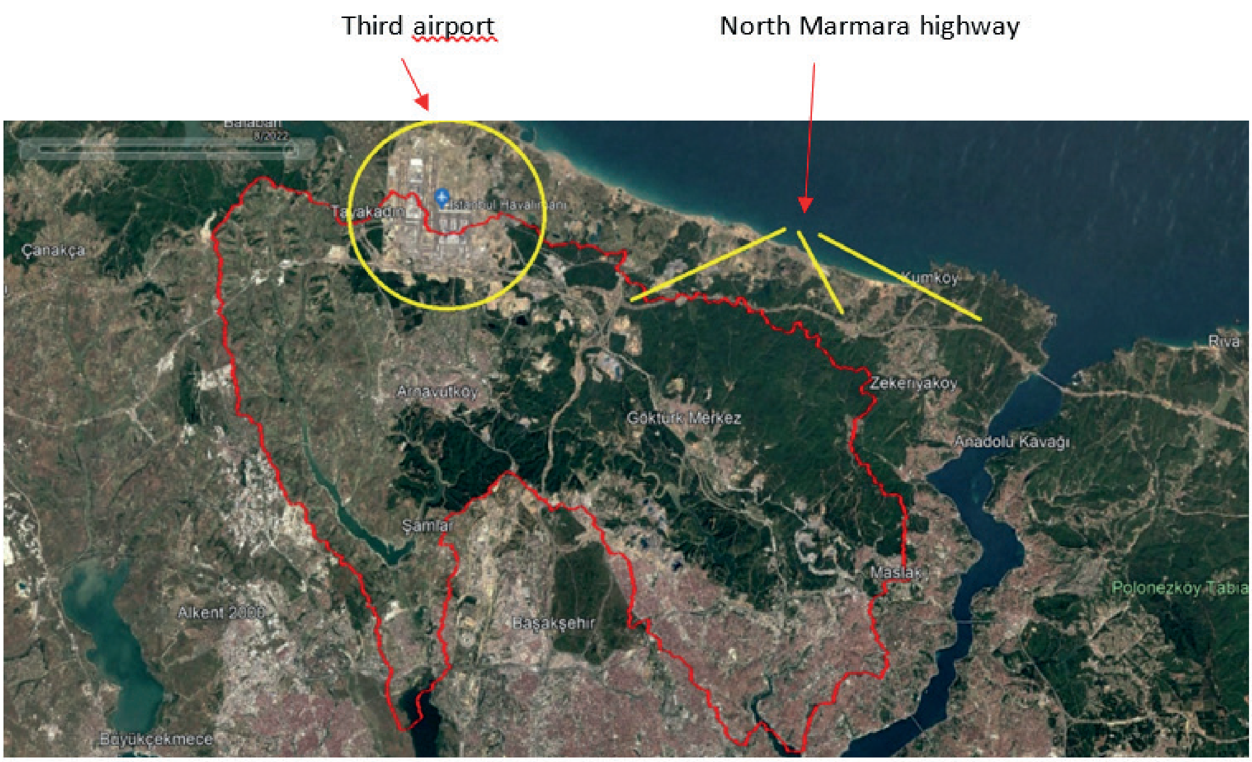

Fig. 2 The land use change in the northern part of the watershed.

INSERT

Pondscapes in Ankara as Green and Blue Infrastructure

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Meryem Beklioğlu, Professor of Ecology, Middle East Technical University, Turkey

Illustration of the planned restoration of the *Gölbaşı Düzlüğü* pondscape. Credit: Oktan Nalbantoğlu, On Tasarım.

Largely neglected and generally undervalued, ponds are remarkably important for biodiversity conservation. The PONDERFUL project investigates how ponds can be used as nature-based solutions for climate change adaptation1. A Horizon 2020 Research and Innovation programme project, funded through the European Union, PONDERFUL brings together leading expertise in freshwater biology and ecology, chemistry, hydrology and social science from across Europe and South America.

In Turkey, the project team at Middle East Technical University has been studying three pondscapes located upstream and to the south of the urban area of Ankara, between the Çölova and İmrahor rivers: their hydrographic profile and their role in the catchments, their physio-chemical and ecological structure including their biodiversity and net carbon contribution, as well as their ownership and management status. Preliminary results show that these ponds provide crucial ecosystem services, notably water quality improvement, water flow regulation, flood prevention, and biodiversity conservation. However, they have so far been neglected and mismanaged, while some have been destroyed following land reclamation. Under the previous municipality, plans to canalize İmrahor river and destroy its surrounding ponds had been approved and construction started. The project has since been stopped.

Today, some of the ponds are being included in a rehabilitation and restoration project which would initiate the creation of a vast green and blue infrastructure in the south of Ankara, centered on these rivers and potentially running all the way to the city center. Whereas many of the ponds are currently net carbon emitters because of heavy land use, mismanagement and the resulting high concentration of nutrients and organic matter, the restoration and the creation of new ponds will contribute to carbon capture, promote biodiversity conservation and improve current ecosystems services, in addition to providing new functions crucial to a periurban environment, such as recreational and educational activities.

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1 For more information, see the website ponderful.eu

IGLUS Quarterly

IGLUS Quarterly is an analytical open access journal dedicated to the analysis of **Governance, Innovation and Performance** in Cities and is edited at EPFL ME, Ras Al Khaimah, UAE. IGLUS Quarterly aims to **facilitate knowledge** and **experience sharing** among scholars and practitioners who are interested in the improvement of urban system's performance in terms of the service efficiency, sustainability and resilience.

IGLUS Quarterly applies the highest academic standards to analyze real world initiatives that are dealing with today's urban challenges. It bridges the gap between practitioners and scholars. IGLUS Quarterly therefore adopts a multidisciplinary perspective, simultaneously considering political, economic, social and technological dimensions of urban systems, and with a special focus on how governance affects and is affected by the use of technologies in general, and especially the pervasive application of the ICTs.

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We are proud to announce that IGLUS Almaty Smart City Lab was inaugurated on 01.04.2022. This is a partnership between the City of Almaty, IGLUS and Kazakh-British Technical University. The lab will organize training programs and conduct research activities for the region. Stay tuned!

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