Designing Environments

Federica Dal Falco *Editor*

Beyond the Garden

Sustainable and Inclusive Green Urban Spaces

Springer

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This series seeks to address the unfolding climate, environmental and ecological crisis from a broad interdisciplinary perspective and in relation to the impact of human transformations of the environment. The aim is to shift away from segregated modifications of the environment divided into domains and scales, systems and objects, with at best minimum negative impact for the environment, towards an integrative interdisciplinary approach that understands, models and modifies the environment in comprehensive and integrative manner and with net positive impact on the environment. This endeavour involves earth, environmental and life sciences, environmental informatics, computer science, and the disciplines that centrally concern the transformation of the terrestrial environments, such as architecture, landscape architecture and urban design, as well as agriculture and food production. From a methodological perspective, computer and data science play a role in facilitating multi-domain and multi-scale models of environments with the purpose of both analysis and design. At the same time, the series will place the discussion in a necessary cultural context and also discuss the need for ethics in which an alternative approach to the transformation of the environment needs to be based on.

The Series Editors welcome book proposals on the following topics: paradigms, theory and methods for integrative inter- and transdisciplinary approaches to understanding, modelling and modifying environments; relevant historical and contemporary case studies; relevant current research projects; related data science and computer science approaches.

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Chapter 2
Avant Gardening to Grow the Green City

Alessandra Battisti and Livia Calcagni

Abstract Changing lifestyles and consumption-production patterns, as well as new highly efficient and soilless cultivation techniques, are evolving the way we design gardens within the city, making not only gardening but also farming possible in places where it was previously difficult or impossible. The garden can be conceived as a green infrastructure in the sense of a linked network of natural and seminatural elements capable of providing multiple functions and ecosystem services with positive economic and social benefits not only for humans. The new productive green city not only consumes less but is itself an autopoietic organism capable of addressing sustainability from not only an agrarian and architectural landscape but also a sociological, psychological, and educational point of view. Four case studies are used to argue whether verticalization is the best way to make cities greener, if the artificial reconfiguration of the environment can ever become a long-established practice, and what benefits does urban green lose when vertical solutions are adopted instead of encouraging direct soil cultivation directly on the ground level.

Keywords Green space · Green infrastructure · Garden · Urban farming

2.1 Introduction

Climate change and the progressive destruction of natural capital as a result of human activity, combined with migratory phenomena, wars, and pandemics, all exacerbated by the economic crisis (World Economic Forum 2023; IPBES 2019), force us to address the unavoidable environmental and social challenges. A wide range of geophysical conditions, including mean surface temperatures, ocean body temperatures, precipitation patterns, oxygen, and ocean acidity, are changing so quickly that nature cannot adapt to them, becoming no longer sustainable for many terrestrial ecosystems (Data-Driven EnviroLab & NewClimate Institute

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2020; European Commission 2015). Among these are ecosystem services necessary to provide goods such as food, fibers, fuels, water, and wood, as well as the regulation of environmental conditions such as pollution control, protection from natural hazards such as floods and forest fires, and water purification, which serve as the backdrop for major recreational, sporting, and cultural activities.

The need for action is urgent: 32% of the world's forests have been destroyed, 40% of invertebrate pollinators are at risk of extinction, and land degradation has resulted in a 23% decrease in land area productivity (WWF 2022; United Nations Convention 2022). The United Nations Global Agenda for Sustainable Development established the Sustainable Development Goals (SDGs) in 2015, indicating, among others, a series of objectives that specifically concern the territory and the soil, which had to be integrated into national short- and medium-term programs and were to be achieved by 2030 (Veerman et al. 2020):

- Ensure that land consumption does not exceed demographic growth.
- Ensure universal access to safe, inclusive, and accessible green and public spaces.
- Establish a land degradation-neutral world as a necessary prerequisite for preserving ecosystem functions and services.

By signing the Agenda, all European Union member states have chosen to participate in a process of monitoring these objectives, which is managed by the United Nations Statistical Commission and is based on the use of an indicator-based system, which includes a specific series of indicators concerning land take, land use, and the percentage of land subject to degradation (Munafò 2021).

2.2 Urban Green Transformation Scenarios

The risks posed by climate change and the alteration of environmental balances urgently call for the adoption of mitigation and adaptation measures (IPCC 2023), which in the urban context take on specific characteristics related not only to the anthropization of the territory, high population density, and mobility but also lifestyles and resource production (World Health Organization 2017). It has now been 7 years since COP21 in Paris, with only 7 years till 2030, the deadline for COP21 signatory nations to reduce emissions by 43% and adjust the track in terms of adaptation, funding, and losses and damages (Moosman et al. 2017). As stated by the United Nations, the world is lagging behind in achieving the Paris Goals, the effort made thus far is completely insufficient, and radical shifts in lifestyles and the way we inhabit the Earth are required if these goals are to be met in an increasingly short time frame (IPCC 2023).

According to sociologist Ulrich Beck, the future is a disease that forces populations to undergo more or less conscious transformations, and in his book *The Metamorphosis of the World*, he argues that in order to understand the metamorphoses of the world, one must investigate new beginnings, focusing on what is emerging from the old and attempting to glimpse future models and norms in the

midst of the present turmoil (Beck 2016). The issues at the root of the change we are witnessing seem to be endemic: the city as the dominant form of living that keeps expanding and consuming land, uncontrolled human densities, vertical urban developments, and stratifications of endogenous social problems. It is urgent to address these issues to ensure not only the well-being of human habitats but also their survival (Brown and Aaron 2001; Battisti 2023). What instead has changed radically is the relationship between nature and artifice, as well as the awareness of the limit that characterizes it. Even before that, now that artificial intelligence can partly replace the human mind, the limit and control of technology has changed the very conception of the connections between the planet, humanity, and nature (Sadin 2018). Already at the end of the last century, the French sociologist Serres claimed in his book "The Natural Contract" that there is a need to establish a new contract that sanctions non-predatory ways of relating to nature and earth, recalling the need to rethink, in light of the natural contract, the profound experience of the sense of a religion (from the etymology of binding, connecting, reuniting) diligent rather than negligent of the world (since negligent is the opposite of religion). To put it in Serres's words "in our exclusively social contracts, we have dropped the bonds that attach us to the world, those that bind temporality to temperature, time to weather, those that put social sciences and physics, history and geography, law and nature, politics and physics, into relation; the bond that directs our language to silent, passive, obscure things that because of our excesses take back their voice, presence, activity, light. We can no longer neglect it" (Serres 1990).

Various tools have been developed at the European level to facilitate the achievement of the objectives of reducing greenhouse gas emissions, with a particular emphasis on decarbonization processes. Urban forestation is gradually spreading in Europe as a measure to increase ecosystem resilience and its capacity to absorb and compensate for external anthropic and natural pressures.

In Asian countries, a global race to build green cities seems to be underway, and this new green growth paradigm is leading to urban planning transformations and changes oriented toward an ecological version of urban entrepreneurship. Urban forestry and gardens are not primarily focused on solving environmental challenges but rather on redesigning urban ecology and the natural landscape at the service of economic competitiveness according to two different modes. The first is of a private, subjective nature and corresponds with the interpretation of forestation as an economic-financial investment project. The second has a public nature and concerns the production mechanisms of design response processes to promote urban health, leveraging the desire to return to living close to nature and promoting green areas with innovative experimental models of urban forestation resulting from the interaction of contemporary actors. In the second case, gardens and urban green spaces reflect identities, dreams, and visions of a near future that does not belong only to the economic or technical-administrative chain. The network must be expanded to include political, institutional, and social actors representing, in various capacities, the socio-technical context within which the green transformation production process takes place.

The subjects are responsible for the final consistency of the work as the tangible output of a culturally embedded manufacturing process. This approach renews and

improves the garden, transforming it from a romantic idyll into a field of technological-environmental experimentation for the fight against climate change, for biodiversity promotion, and for the realization of social justice principles, transforming gardens into avantgarde places capable of mediating urban metamorphoses through processes of collective action, the comprehension of which is problematic but oriented straight ahead to a truly sustainable future.

2.3 Avant Gardening

The garden, as an idealized space that pervades our daily lives and imaginations, is a place where practical function and symbolic meaning merge and where the design and construction of experimental spaces can implement advantageous urban policies ranging from didactic-educational lessons to the creation of real financial modeling tools, all based on best practices and experimental data provided during the last few decades. We are witnessing design processes that involve expanding networks of financial partners and equipment linking project developers with innovative and evolutionary technologies for the production of ornamental and agricultural plants. There are several potential urban gardening possibilities that become sites where social justice and public involvement are disclosed and negotiated, ranging from social to political and financial interests and related to cultural value systems. As urban densities rise and land availability decreases, green spaces within cities tend to find space vertically: vertical gardens, farms and forests, rooftop gardens, and elevated structures for urban agriculture. These projects demonstrate the wide range of plant cultivation techniques—whether for human use or not—in different ways than the traditional ground-zero soil cultivation practice. Although vertical greenery can take many forms depending on the structure, the species, and the context, all of these solutions have one thing in common: they optimize open green areas while consuming as little horizontal space as possible. In this sense, the already widely recognized impact of plants on cities takes on a new dimension as a result of verticality. These alternative farming methods are used to reduce heat islands, increase biodiversity, promote food security, improve air quality, and reduce CO2 emissions, among other benefits.

2.4 Visionary and Unusual Avant Gardens: Blurring the Lines Between the Natural, the Artificial, and the Cultivated

Some questions arise spontaneously, and many wonder if verticalization is the best way to make cities greener and if the artificial reconfiguration of the environment can ever become a long-established practice. What are the long-term consequences of

these activities in cities? Furthermore, what benefits does urban green lose when vertical solutions are adopted instead of encouraging direct soil cultivation directly on the ground level? The garden can be conceived as a green infrastructure in the sense of a linked network of natural and seminatural elements capable of providing multiple functions and ecosystem services with positive economic and social benefits for humans and other species (Benedict and McMahon 2012; Pitman et al. 2015; Naumann et al. 2011; Williamson 2003).

Blurring the lines between the natural, the artificial, and the cultivated, four very different projects are proposed as visionary and unusual *avant gardening* concepts that reflect the shifting mindset and cultures of their specific time and space. The case studies are thoroughly investigated in order to argue the advantages and disadvantages of vertical greenery in its broader sense. The projects have been analyzed according to different perspectives (location, spatial arrangement, functional purpose, and tenure) and to their compliance with the following parameters: minimum land footprint, microclimate improvement, biodiversity increase, CO_2 reduction, resource circularity, food security promotion, and social catalyst role.

2.4.1 Shiseido Forest Valley

The Shiseido Forest Valley (Fig. 2.1) is one of Asia's largest indoor gardens, spanning five stories and approximately 22,000 m^2 located in the heart of Jewel Changi Airport. It houses around 3000 trees and 60,000 shrubs of 120 species that live in high-altitude tropical forests from around the world and a 40-m-high indoor rainwater waterfall running through the middle of the garden that can channel 10,000 gallons of water a minute. The greenhouse houses shops and public spaces. The Airport is re-imagined as a major public realm attraction and vibrant urban center, which combines an intense marketplace and iconic gardens to create a new community-centric typology hub (Doe 2000). The vertical indoor garden offers travelers and visitors perfect microclimate conditions, unusual green and fresh spatial experiences, and contact with nature within the city (Safdie Architects 2023; Raut 2019). The indoor garden is not really open to the public, as visitors must pay an entrance ticket for most of the attractions, like the Canopy Park and Bridge, the Hedge Maze, and Foggy Bowls. Thus, it cannot be entirely considered a public green space open to the citizens. Moreover, although irrigation is provided thanks to rainwater collection, maintenance costs, and energy consumption are extremely high. In fact, indoor plants depend on artificial conditions for light, temperature, and humidity, making them more dependent on human intervention compared to outdoor gardens.

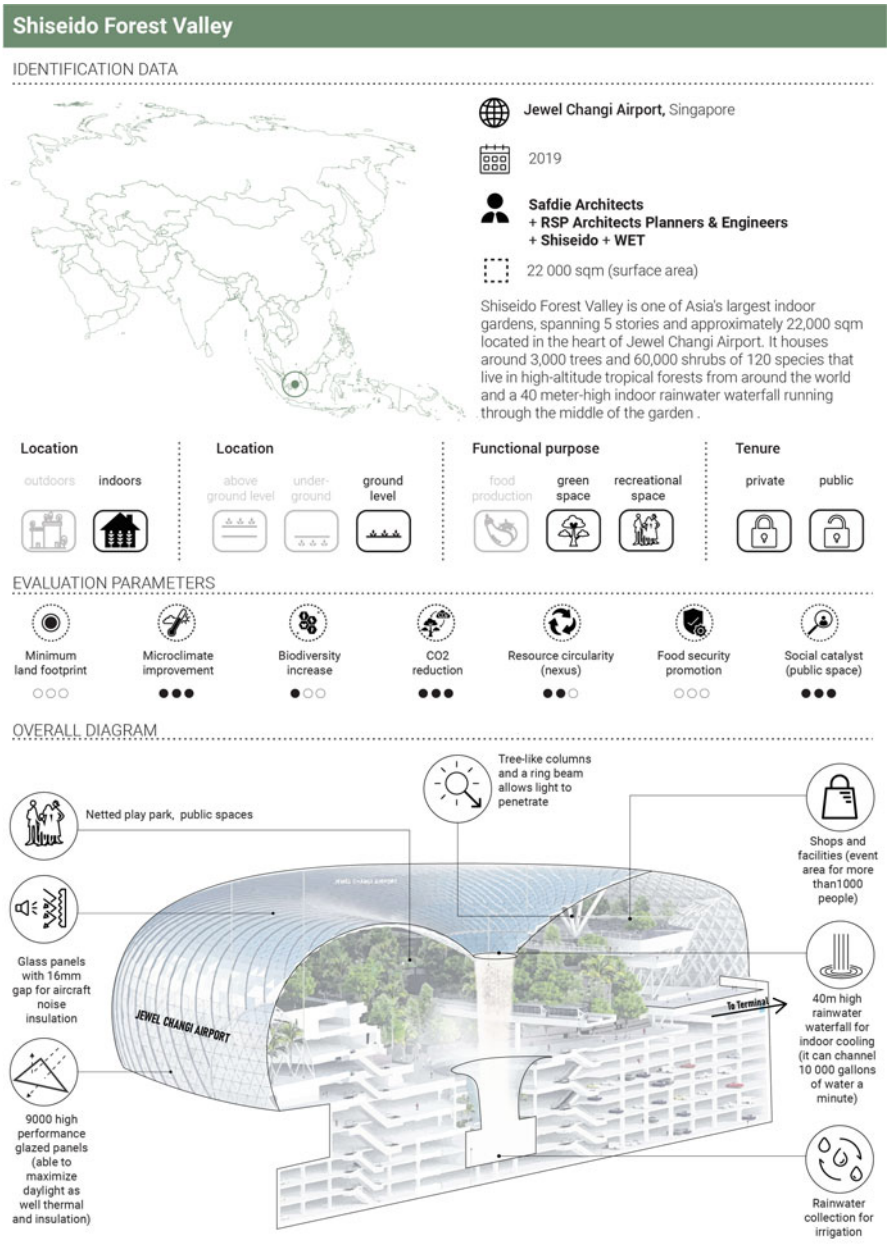

Fig. 2.1 Shiseido Forest Valley in Singapore Jewel Changi Airport with an indoor garden spanning five stories and a waterfall. (Source: Authors' elaboration)

2.4.2 Growing Underground

Another extremely interesting indoor garden is Growing Underground (Fig. 2.2), an underground farm located in London's former air raid shelters. In this case, urban gardening takes the form of urban agriculture using controlled environment techniques and hydroponics as an alternative local source of food. Integrating urban farms within dense environments using unused spaces, hardly usable for any other purpose, has the potential to use waste infrastructure and resources within cities and at the same time provide jobs and improve food security. The hydroponic system does not make use of pesticides and recirculates water (Chutiphongdech 2020). In order to optimize the use of resources and energy, a network of 25 sensors is installed in order to constantly monitor temperature, relative humidity, CO_2 concentration, air velocity, light levels, and several other parameters, which strongly affect the crops' growth. The sensors transmit data to loggers that are configured to process the data, and a web platform (digital twin) is used to visualize in real time the data acquisition (Walsh 2021; Jans-Singh et al. 2019). Moving production underground frees up more space on the surface to host a growing population and at the same time gives a new function to abandoned unused spaces. But in social terms, a subterranean garden doesn't provide a pleasant space for social interaction and engagement and has limited accessibility and nonoptimal comfort conditions for users.

2.4.3 Soradofarms

Reusing urban voids, leftover spaces, or empty unused spaces to provide the city with green infrastructure is a widespread strategy. Unused spaces are not only underground tunnels, as in the Growing Underground project, but also empty parking lots or small plots between buildings or even rooftops. Rooftop gardens and farms have been established all over the world to enable growing food in dense urban areas. In Japan, a whole new kind of urban rooftop farm was opened recently. Soradofarm (Fig. 2.3) is an urban agriculture project that uses the rooftops of train stations to accommodate urban gardens for commuters that want to use their transfer time to relax, regain connection with nature, and train their gardening skills (de Boer 2014). At the five rooftop allotments of Soradofarm, commuters can jump out of their busy lifestyles to grow fresh food. The train station rooftop farms act as urban catalysts, providing a multifunctional outdoor garden where commuters and their families as well as locals who have no space for a private garden can enjoy open-air time while engaging in community activities like farming, playing, or even having a picnic (Taramanni 2015). Moreover, the decentralized reconversion of concrete rooftops in urban community gardens contributes to the environmental maintenance and revitalization of the areas along the railway line.

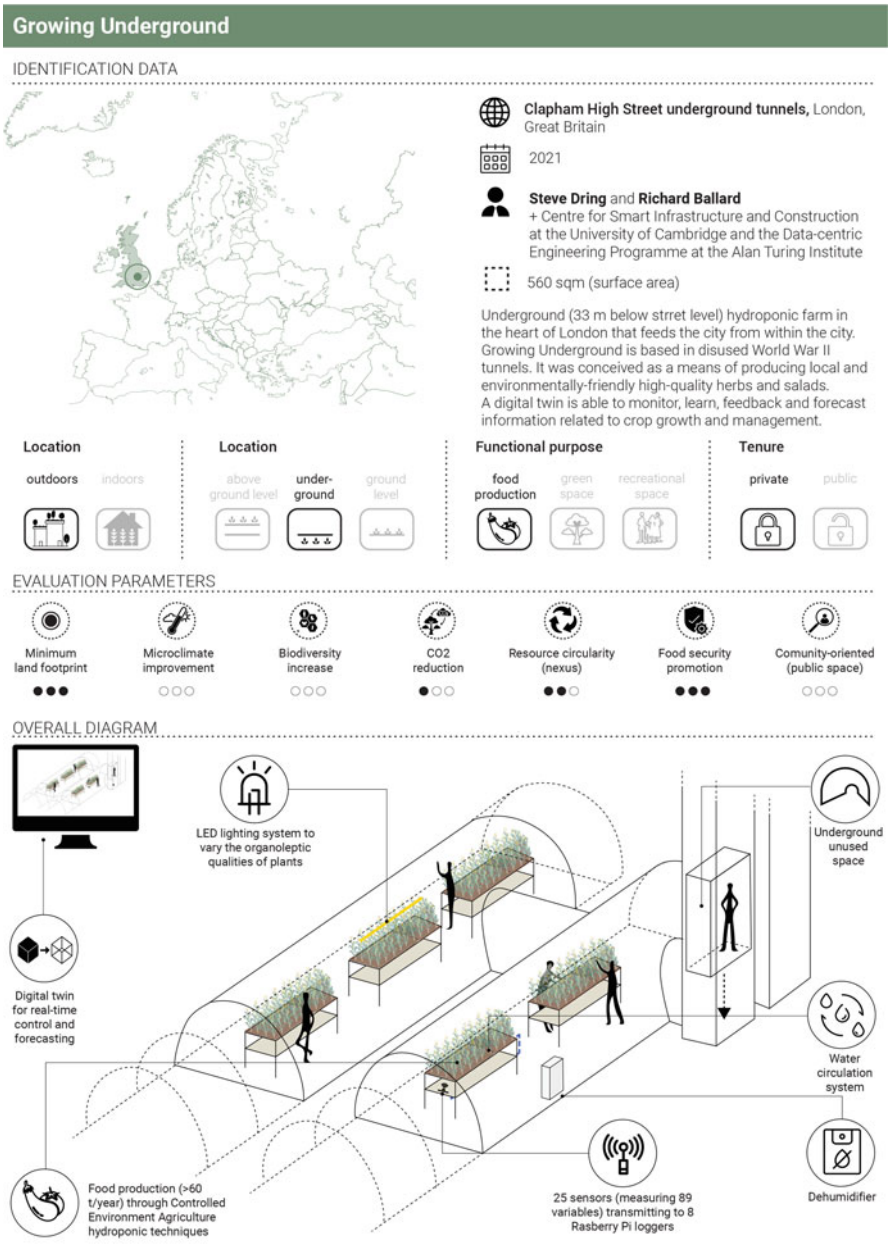

Fig. 2.2 Growing Underground in London's former air raid shelters in Clapham Highstreet underground tunnels: indoor hydroponic farming facility. (Source: Authors' elaboration)

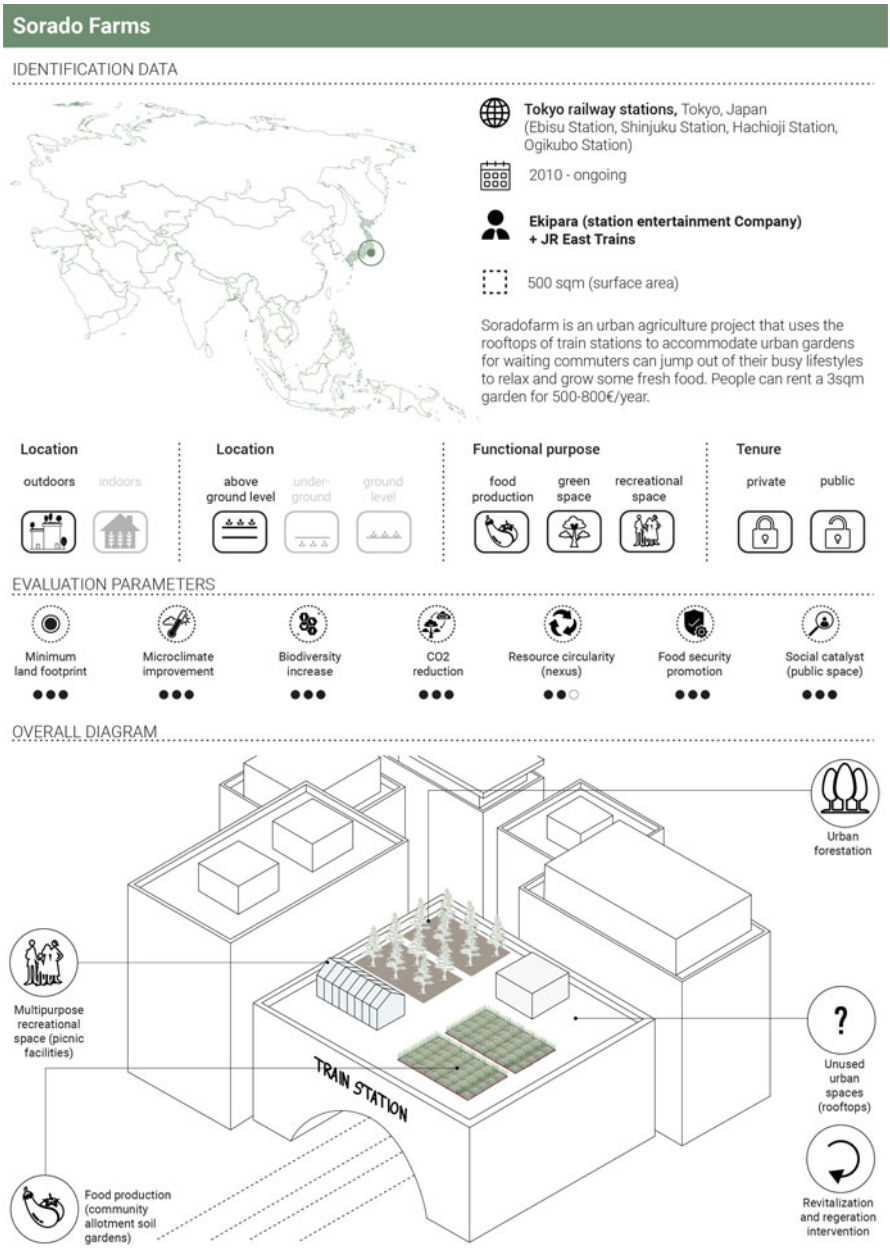

Fig. 2.3 Soradofarm on Tokyo's railway infrastructure: rooftop farming. (Source: Authors' elaboration)

2.4.4 Impact Farm

Since many cities around the world are pockmarked by empty, underused space, food deserts, and endemic underemployment, urban farms are gradually gaining ground as a potential solution to all such problems. An example of optimizing urban unused voids while enhancing the urban fabric in terms of social vitalization, microclimate improvement, and environmental reconversion is impact farm (Fig. 2.4), a greenhouse pop-up urban model that can easily squeeze into tight, urban spaces. The greenhouse provides a small-scale solution within 50 m^2 designed to be highly efficient not only in terms of food production but also in terms of water and energy consumption (Goldapple 2015). Irrigation is sourced from rainwater collection, and water is recirculated within a closed-loop system. The method of hydroponic cultivation results in significant savings in the use of freshwater at 70–85% compared to more conventional methods of production (UIA 2023). Moreover, the farm is designed for disassembly allowing for temporary leasing and site relocation, which represent a common challenge in metropolitan areas (UIA 2023). On the ground level, the farm is designed as a social space for community building. In the prototype built in Copenhagen, the farm has raised awareness of urban farming and its benefits through educational workshops, concerts, and food festivals. The goal is to create an economically sustainable urban garden that can both ensure resource-efficient local food production, create green jobs, and increase local economic activity (The Index Project 2023) while providing a neighborhood meeting place in a transitional space that is in between outdoors and indoors.

2.5 Conclusions

Overall, the concept of garden reveals to be quite broad encompassing indoor, outdoor, and transitional spaces; public and private tenure; and a wide range of functions ranging from recreation facilities to food production.

The indoor garden at Singapore Changi Airport and the rooftop gardens on Tokyo's train stations are conceived as public spaces within or on top of public mobility facilities, but in practice, they are intended only for privileged users. In the airport's case, the garden can be accessed by non-travelers only by paying an entrance ticket. In Tokyo, people can use the gardens and access the rooftops only by paying a yearly rent of about 500–800€. Because of its limited accessibility, linked to economic disparity, the "public" space loses its role as a social catalyst and its democratic nature.

The increasing demand for food, the lack of natural resources and arable land, and the urgency of limiting energy consumption have largely contributed to the evolution of the traditional garden into a food-producing garden. As shown by the case studies Growing Underground and Impact Farm, hydroponic farming is gaining popularity all over the world because of efficient resource management, land-use

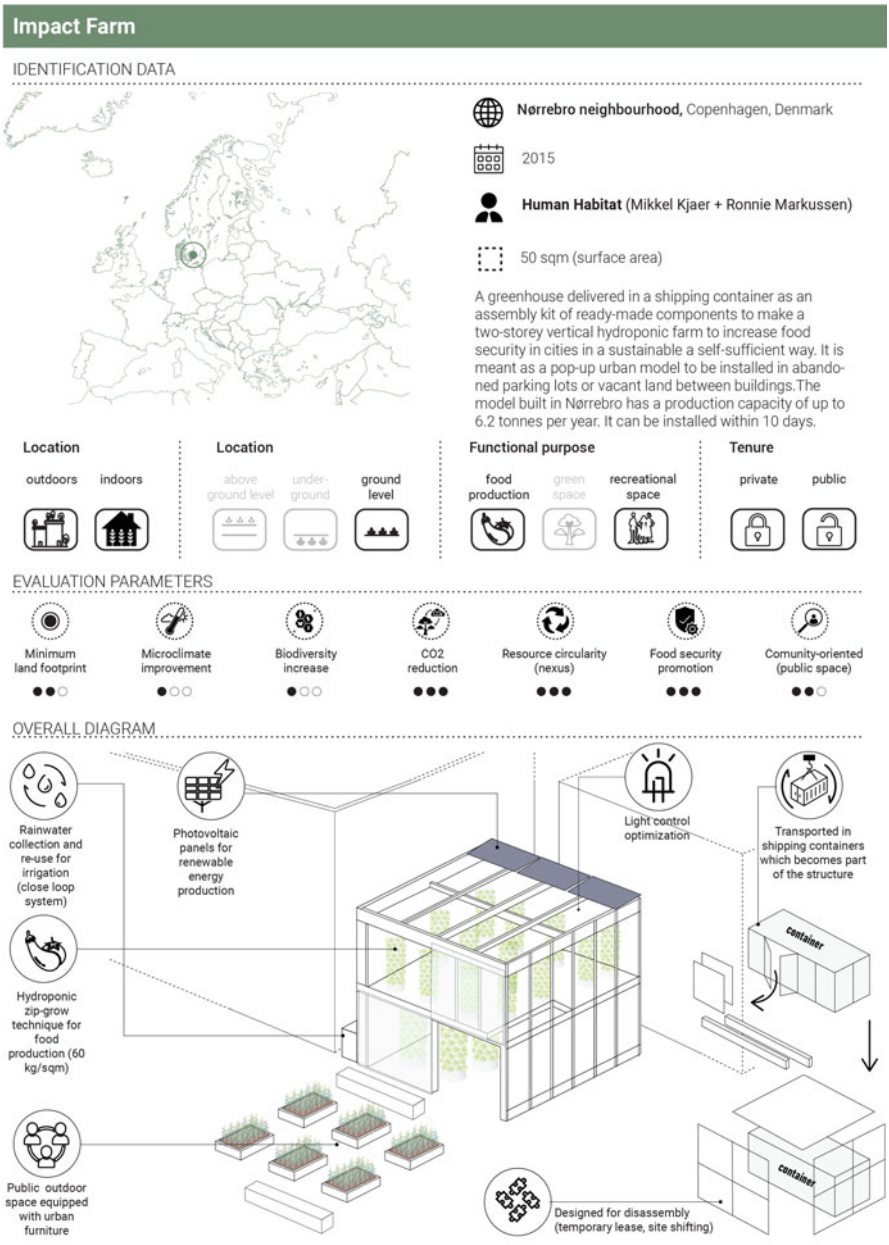

Fig. 2.4 Impact farm in Copenhagen: pop-up urban vertical garden for vacant and/or unused plots in cities. (Source: Authors' elaboration)

efficiency, planting environment cleanliness, fertilizer and resource saving, and quality food production. Soil-based agriculture is now facing various challenges such as urbanization, extreme weather events and natural disasters, and indiscriminate use of chemicals and pesticides, which is depleting the land fertility. However, as highlighted by the Soradofarms project, conventional cultivation requires less investment and technical know-how, making it more accessible for now. As a result, developing low-cost techniques that are easy to operate and maintain, require less labor, and lower overall setup and operational cost is crucial for successful implementation of commercial hydroponic technology. In light of these considerations, conventional cultivation methods and hydroponics and/or aeroponics techniques are likely to coexist in the coming decades, since they provide different benefits according to the context needs and function.

Moreover, focusing on the social role of gardens and green infrastructure, whether plants are grown using hydroponic techniques or soil is not important, since the purpose concerns the overall integrated benefits provided by the green space. Because of the unbearable temperature, humidity, lighting, and ventilation conditions, a subterranean garden will hardly be used as a gathering place or recreational space. However, thanks to controlled environment techniques, it is ideal for producing food. Although hydroponic techniques can be extremely beneficial for narrow spaces between buildings, along facades, and in other residual urban spaces, they may not always be the best solution for rooftop gardens for instance. As shown in the Soradofarm example, the green roof also serves as a means to improve indoor comfort conditions in the building, as the soil layer acts as a powerful insulating layer. These considerations highlight how different sites, in terms of morphological, dimensional, and microclimate conditions, require different solutions.

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