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Integrating Bioevolutionary Urban Farming Practices for Sustainable and Resilient Cities: Benefits and Challenges

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Abstract

As cities continue to grow, the strain on local and global natural ecosystems intensifies, leading to increased demands for resources and the generation of waste and emissions. Traditional linear models of resource consumption in cities are not sustainable in the long run. The essay highlights various challenges. It explores the complexities of integrating bioevolutionary approaches within urban environments and building design and discusses potential strategies to overcome these challenges. By understanding and addressing these obstacles, cities can effectively harness the benefits of bioevolutionary urban farming for a more sustainable future

Key words:

bioevolutionary urban agriculture, regenerative design, resilient cities

Introduction

Cities have increasingly placed a significant burden on local and global natural ecosystems, leading to resource depletion and escalating waste generation. This trend poses considerable challenges as urban populations continue to grow, resulting in the expansion of urban land, heightened demands for food, water, and energy, and a surge in waste production (Ash et al., 2008). Cities are major contributors to global energy consumption, accounting for approximately 75% of the total, and are responsible for approximately 80% of greenhouse gas emissions (Ash et al., 2008). Projections indicate that by 2030, the urban population will comprise roughly 60% of the world's total population (United Nations, 2008). As a consequence, global primary energy demand and associated greenhouse gas emissions are predicted to rise by 40% compared to 2007 levels (IEA, 2009). Addressing sustainability concerns and incorporating new design principles into urban growth is thus a critical challenge for the twenty-first century (Alberti, 2008).

The prevailing model of cities is characterized by linear flows of resources, with imports of non-renewable resources and exports of emissions and waste. The current linear flow of food to cities results in high energy consumption and significant waste generation and CO2 emissions per unit of food throughout its life cycle (EEA, 2010). When considering the complete value chain from production to waste, agriculture globally contributes to approximately one-quarter of annual greenhouse gas emissions, underscoring the urgent need for the global food system to reduce its climate impact (EEA, 2010).

To create a sustainable urban model for the future, there is a need to foster integrated flows between the natural environment and urban industrial subsystems. This necessitates the symbiotic integration of energy, water, materials, and natural resources inflows with emissions outflows from the urban system (Saheley et al., 2003). Urban and peri-urban agriculture, integrated into the urban economic and ecological systems, offers an opportunity to optimize urban space (Viljoen et al., 2005). However, current agricultural practices in cities primarily focus on scientific approaches, lacking the exploration of successful bioevolutionary patterns observed in nature. Moreover, the human need for a connection to nature and its influence on well-being are often overlooked (Viljoen et al., 2005).

In light of this, the integration of urban farming based on bioevolutionary approaches becomes a promising avenue to explore. By aligning strategies with nature's evolution, human biology, and the built environment, urban farming can not only contribute to ecological sustainability but also address the human need for a connection to nature and improve overall well-being. These considerations can guide the development of more resilient and sustainable cities in the future.

Research Question

"What are the potential benefits and challenges of integrating bioevolutionary urban farming practices in cities to achieve sustainable and resilient urban environments?"

Research Sub-questions

1) What are agricultural practices, movements, their consequences, weaknesses, and potentials?

2) How does agriculture affect citizens?

3) How does urban agriculture affect architecture and building design? What are the main challenges, concerns, and emerging design considerations?

Agriculture

Scientific Farming - Farming without Nature

Scientific farming, also known as farming without nature, is characterized by the full automation and systematization of production. It represents a trend towards mechanized agriculture, where the focus is on maximizing productivity and efficiency through technological advancements. One area where scientific farming excels is in growing produce in unnatural environments and under unnatural conditions. This approach caters to the demands of the consumer public that desires agricultural products out of season or ones that nature cannot naturally provide. By leveraging controlled environments and advanced techniques, scientific farming enables the production of crops year-round, regardless of the natural growing season.

However, it is important to note that scientific farming is not necessarily more economical or productive compared to traditional farming methods. Its profitability lies in the skillful utilization of time and space to create profit. While scientific farming harnesses the knowledge and forces of nature through human intellect, it remains limited to the existing research findings and current human understanding.

Various techniques and systems fall under the realm of scientific farming, including rooftop greenhouses, aquaponics, hydroponics, LED farming, and controlled environment farming. These methods employ cutting-edge technology and precise control over environmental factors such as temperature, light, and nutrient levels to optimize crop growth and yield.

While scientific farming offers unique advantages in terms of flexibility and product availability, it is essential to carefully consider its implications. Balancing the benefits of year-round production and increased productivity with the potential environmental impact, resource consumption, and the need for sustainable practices is crucial.

In summary, scientific farming represents a departure from traditional farming practices, emphasizing automation, systematization, and the manipulation of growing conditions. It enables the production of crops in unnatural environments and out of season, catering to consumer demands. However, its economic viability and overall productivity depend on the skillful use of time and space. Scientific farming is an ever-evolving field, limited by the current understanding of nature and the capabilities of existing technologies and knowledge.

Biomimicry in agricultural approaches

Biomimicry short introduction

Biomimicry is a design approach that draws inspiration from nature's efficient processes and interrelationships (Benyus, 1997; McGregor, 2013). It involves mimicking functional systems and processes found in nature to find effective solutions to design problems. Janine Benyus introduced the concept, highlighting nine functioning principles of nature that reflect features of ecosystems (Benyus, 1997; McGregor, 2013). Biomimicry can occur on different levels and dimensions, including form, material, construction, process, and function (El Ahmar, 2011). It has the potential to provide solutions in various areas such as waste reduction, efficient manufacturing, and sustainable design (Pawlyn, 2016; Benyus, 1997; McGregor, 2013). Learning from nature in biomimicry goes beyond analogy and emphasizes concrete data and a deep understanding of natural processes (Zari, 2007; Speck et al., 2017).

Do nothing Farming - The natural way of farming

This type of farming eliminates the unnecessary practices in agriculture. The four principles of natural farming are no-tilling (cultivation), no fertilizers, no weeding, and no pesticides (Fukuoka and Metreaud, 1993). No tilling refers to not turning over or plowing the soil, rather the soil cultivates itself through the penetrating roots of the plant, the earthworms digging through, the microorganisms moving through, and other small animals. No chemical fertilizers or prepared compost are used, rather the soil maintains its own fertility with respect to the cycles of the plants on the site. Weeds are not removed by herbicides or cultivation, as they play an essential part in the soil's fertility, but rather they are controlled. No pesticides refer to using nature's way to keep the balance of harmful insects and diseases. They are always present, however, in a natural system they don't exceed a level that requires chemical force to deal with the imbalance. Growing sturdy crops in a healthy environment is key.

The same piece of land can be used long-term without being used up. Instead of continual investments of money and energy and water flows into the farm, most investment is made upfront in the design of the farm (Benyus, 1997). The name comes from the concept that the farmer is just a mitigator and that nature is doing most of the work in the way it knows. Some of his techniques consist of using clay pallets or clay balls containing the seeds that are just tossed around in the field, while the clay eventually dissolves it protects the seed from birds and rodents. Growing trees from seed, as in this way they develop a naturally-efficient central leader branching system. Having a diversity of plants growing next to each other species is seeded when it would choose to seed naturally. Using natural crop rotations . When harvested everything is returned to the field except the grain. The straw from the cut acts as a mulch.

The methodology is used worldwide with great success in yields. Originally in Japan, its main crop is rice and it has the best yield in the country. Its methodology is being spread throat the world and multiple places like Greece, Spain, and Chile report having much higher yields than compared to chemical farming methods. The methodology is designed for the production of the agricultural mainstays: rice, barley and wheat, but it integrates the production of all different crops shown in Figure X. Synonyms of this methodology are natural farming, organic farming, Fukuoka farming, and some branches including specific focuses of the methodology are no-tilt farming, and zero-budget natural farming.
Yields and places*

Forestry - farming in succession

Forest in succession as a conceptual guide for self-sustaining farms. Every living component has multiple functions—shading, fertilizing, and yielding an edible harvest. Wherever possible, the work of machines (and, by extension, humans) is replaced by the work of biological organisms or systems (Todd, 1994). Successional or ecological agriculture adapts to changes over time. In early phases, annual crops and fish ponds dominate the landscape, but as the landscape grows and matures, a third dimension develops as tree crops and livestock come into their own. The key is to mirror the natural tendency of succession which, over time, creates ecosystems that are effective and stable utilizers of space, energy, and biotic elements."

Synonyms are food forest, agroforestry, successional farming, ecological agriculture, and agroecological farming Agroforestry is a science-based land-use system that combines diverse edible plants, crops, trees, and shrubs to achieve financial and environmental goals (Nair, 1993). By emulating the structure and functioning of natural ecosystems, agroforestry creates an agroecological cycle and chain of processes that enhance the functionality and sustainability of the farming system (Nair, 1993). This approach allows for a greater number of plants to be cultivated in a given area without causing failure due to competition (Nair, 1993).The practice of agroforestry brings numerous benefits. It enhances crop yield, providing a wide range of useful and marketable products (Nair, 1993). This diversification contributes to increased income for farmers and promotes biodiversity by creating habitats for various plant and animal species (Nair, 1993). Additionally, agroforestry improves soil structure and health, reducing erosion and enhancing carbon sequestration (Nair, 1993). In discussions about the productivity of forests versus farmland, Greg Williams argues that forests become less productive as they mature due to ecological succession (Williams, 1997). However, proponents of permaculture counter this argument by stating that the decline in productivity occurs when comparing woodland forests to climax vegetation, but not when comparing farmland vegetation to woodland forests (Mollison, 1988). They point out that ecological succession generally leads to rising productivity until reaching the woodland state (67% tree cover), after which it gradually declines until full maturity (Mollison, 1988).

Overall, agroforestry offers a sustainable and productive approach to land use, incorporating the principles of ecological diversity and natural processes (Nair, 1993). By integrating trees, crops, and other plants, agroforestry systems can enhance agricultural output while promoting environmental conservation and resilience.

Regenerative agriculture

Regenerative agriculture is a term growing in popularity and research . Thus also it has many synonyms such as "sustainable agriculture", "agroecological farming" "alternative agriculture," "biodynamic agriculture," "carbon farming," "nature inclusive farming," "conservation agriculture," "green agriculture" (Newton et al., 2020). All these terms do not point at a certain practice but rather a combination of very different methods that have a certain input and output. The definition is wide and broad among research papers and the analysis of 209 summarises the following overlapping criteria for sustainable agriculture among the analyzed papers (Newton et al., 2020). The most common criteria are in inputs- reduced tillage, integration livestock, using no to minimal external farm inputs and maximizing farm inputs, cover crops and crop rotations, use of compost, green manure, mulch, and crop residues. And the outcomes are to improve soil health, carbon sequestration, water health, ecosystem health, increase biodiversity, and improve the social and well-being of communities (Newton et al., 2020)

Conclusion

Overall, these farming approaches emphasize working in harmony with nature, utilizing natural processes, and promoting sustainability. By embracing these methodologies, farmers can cultivate food while preserving and enhancing the health of the environment and communities.

Agriculture and Citizens

Biophilia - Human's biological need to connect to nature and all living things (scientifically proven)

Neurological research and experiments have demonstrated that humans are dependent on the existence of nature-connecting qualities in their environment. It is essential for their sense of belonging and well-being and the main source of "neurological nourishment" (Salingaros and Masden, 2008). Humans have an inborn craving for this type of information that is associated with the brain's pleasure centers, which also controls the reduction of pain" (Biederman and Vessel, 2006). The theory of biophilia claims that human health and well-being have a biologically based need to affiliate with nature and all living things developed by E.O Wilson (Wilson, 1993). Improving humans' visual environment is equally important to reduce the energy use of buildings (Kellert, 2005) and biophilia is "the missing link in sustainable design" (Ramzy, 2015). The paper *14 Patterns of Biophilic Design* elaborates on the relationship between nature, human biology, and the built environment so that the human design can lead to the benefits of biophilia: (Ryan et al., 2014)

Agriculture being integrated into the urban form and daily experiences of the people also carry a big responsibility for the well-being of people. What is more, agriculture as part of nature has great potential for biophilic integration into design. Urban agriculture has the potential to increase nature in the city and also increase access to nature.

Permaculture

Permaculture, a design approach based on environmental observations and the nurturing of relationships between people and land, emphasizes the ethics of caring for the earth and caring for people (Mollison, 1988). While permaculture draws inspiration from scientific fields, formal research to understand its practices has only recently been conducted (Mollison, 1988). One of the key principles of permaculture is the design of different zones within projects, including areas for planting, recreation, community activities, and food production (Mollison, 1988). By carefully planning and organizing these zones, permaculture aims to create sustainable and productive landscapes that meet the needs of both humans and the environment.

Despite its popularity, permaculture has faced criticism for being poorly defined and lacking scientific rigor (Harper, 2016). Critics argue for a greater emphasis on peer-reviewed research to support claims of productivity and to clarify methodology (Harper, 2016). Peter Harper, from the Centre for Alternative Technology, suggests that much of what is attributed to permaculture may not address real-world challenges effectively (Harper, 2016). Permaculture serves as a social approach to connecting people with food production and sustainable land use. It integrates ecological principles with human needs and aims to create resilient and productive systems that foster community engagement (Mollison, 1988). Further research and scientific validation are necessary to better understand and refine the practices associated with permaculture (Harper, 2016).

Conclusions

In conclusion, permaculture holds great potential for positively impacting citizens and promoting food security. By adopting permaculture principles and practices, communities can empower individuals to actively engage in sustainable food production, create resilient local economies, and cultivate a sense of connection to nature and community. Permaculture encourages citizen involvement and participation in shaping their environment and food systems. Through collaborative decision-making and shared responsibilities, individuals can gain practical skills in sustainable agriculture and ecological design, fostering a sense of self-reliance and empowerment.

Moreover, permaculture promotes the cultivation of shared resources and the development of local food systems. Community gardens and urban agriculture initiatives provide opportunities for citizens to grow their own food, share surplus produce, and support local economies, contributing to enhanced food security and resilience.By integrating permaculture principles into urban design and public spaces, citizens can reconnect with nature, experience the benefits of green spaces, and improve their overall well-being. The cultivation of food-producing landscapes in cities not only enhances food security but also strengthens social bonds and promotes a sense of belonging within the community.

Overall, permaculture offers a holistic approach to sustainable living, fostering citizen engagement, promoting food security, and creating resilient and vibrant communities. Its principles have the potential to transform our relationship with the environment and empower individuals to actively contribute to a more sustainable and secure future

Agriculture and Building Design

This section of the paper answers the sub-question: How does urban agriculture affect architecture and building design? What are the main challenges, concerns, and emerging design considerations?

Structural Design

Buildings structure needs increased load-bearing capacity. This holds especially for urban agriculture on the roof. The weight of soil, plants, and water in a rooftop garden or greenhouse can range from 45 to 850 kilograms per square meter (kg/m2), depending on the depth of the soil and the type of plants being grown. This means that buildings must be designed to support additional loads ranging from 1.0 to 4.0 kg/m2 (Green Roof Professional certification program). For comparison, typical roofs in residential buildings are designed to support loads of 2.5 to 3.8 kg/m2, while commercial roofs can support up to 11.3 kg/m2 (Green Roof Professional certification program). This additionally results in increased foundation design. The foundation may need to be designed to withstand vertical loads of up to 180 kg/m2, which is much higher than the typical design load of 12.2 to 24.4 kg/m2 for residential or commercial buildings. (Green Roof Professional certification program). Additional green walls and vertical gardens that are attached to walls have varying weights depending on the type of plants used, the growing medium, and the structural support system. The additional weight can vary between 30 to 150 kilograms per square meter (Lui et al., 2019). This requires a more durable, stronger material, which increases the cost. See
Figure 1. Green Roof depth and weight considerations for loadbearing capacity for specific data.

Water management

As a general guideline, rooftop gardens, and greenhouses typically require more frequent watering than traditional ground-level gardens. This is because rooftop gardens may be exposed to more sun and wind, which can cause the soil to dry out more quickly. Additionally, rooftop gardens may not have access to natural sources of water, such as groundwater or surface water, and may rely solely on rainwater or municipal water supplies. What is more, research suggests that vertical gardens also generally require more water than traditional gardens (Fernandez-Cañero & Castro, 2017; Wong, Tan, & Tan, 2009). This is primarily due to factors such as the vertical orientation, compact planting arrangement, and the use of specialized growing mediums in vertical garden systems (Fernandez-Cañero & Castro, 2017). Vertical gardens often have limited soil volume, which can result in faster drainage and increased water evaporation (Wong, Tan, & Tan, 2009). Therefore, it is important to provide adequate irrigation to ensure the plants receive sufficient moisture. However, it is worth noting that specific water requirements can vary depending on various factors such as plant selection, climate conditions, and the type of irrigation system used (Santamouris, Kolokotsa, & Synnefa, 2016; Wong, Chen, & Ong, 2003).

According to a research study conducted by the University of Arizona Cooperative Extension, the water requirement for rooftop gardens and greenhouses can vary depending on factors such as crop type and growing conditions. It is estimated to range from 5 to 25 liters per square meter per day (L/m2/day). This is equivalent to 0.5 to 2.5 millimeters per day (mm/day) of water or approximately 182 to 912 millimeters per year. Rainwater harvesting is a commonly used method for managing water in rooftop gardens. This approach involves capturing and storing rainwater for irrigation purposes. It can be achieved by installing rain barrels or cisterns on the roof or incorporating larger-scale rainwater harvesting systems into the building's plumbing (Liu & Bogue, 2017). This approach helps reduce the reliance on external water sources and promotes sustainable water use. Implementing efficient irrigation systems is another crucial aspect of water management in urban agriculture. Drip irrigation systems, for example, use small tubes to deliver water directly to the plant's root zones, minimizing water loss through evaporation and ensuring efficient water distribution (Liu & Bogue, 2017). Overhead sprinkler systems can also be employed, although they may lead to higher water consumption due to potential water loss through drift and evaporation (Liu & Bogue, 2017). Proper drainage systems are essential to managing excess water in rooftop gardens. The University of Arizona Cooperative Extension (n.d.) suggests two common methods: subsurface drainage and above-ground drainage. Subsurface drainage involves the installation of perforated pipes or channels beneath the soil to collect excess water and direct it to a drain or outlet. This method helps maintain a consistent soil moisture level and prevents water pooling on the surface (Liu & Bogue, 2017). Conversely, above-ground drainage systems use gutters, downspouts, and channels on the garden's surface to collect and channel excess water to a drain or outlet. However, this method may be less effective at managing excess water and could potentially cause soil erosion or water damage to the building (Liu & Bogue, 2017).

Light

Careful planning and consideration of the orientation of the rooftop garden, the placement of plants, and the use of shading devices can help to maximize natural light and create optimal growing conditions. The amount of daylight required for open rooftop agriculture can vary depending on the specific crops being grown and the climate of the region. Generally, most plants require at least six hours of direct sunlight each day for optimal growth (Green Roofs for Healthy Cities, n.d.). However, some crops, such as leafy greens, may be able to tolerate less sunlight and can thrive with just a few hours of direct sunlight each day (Green Roofs for Healthy Cities, n.d.). In addition to direct sunlight, plants also benefit from indirect or diffused sunlight, which can help to promote healthy growth and development. Indirect sunlight can be obtained through reflective surfaces or by positioning the plants in locations where they receive some sunlight but are shielded from direct sunlight for part of the day (University of Minnesota Extension, n.d.). In general, an orientation that maximizes exposure to sunlight and minimizes exposure to shade is ideal. In the northern hemisphere, a south-facing orientation is typically preferred to maximize sunlight exposure (Philips, 2013). "The amount of sunlight required varies across different plant species and also with the time of year, with more sunlight needed in winter months. Therefore, the orientation of the rooftop garden should be selected based on the plant species being grown, the microclimate of the rooftop, and the desired yields." (Philips, 2013).

Wind

Wind can have a significant impact on the design and functioning of an urban rooftop garden. Strong winds can damage plants and structures, disrupt irrigation systems, and even cause soil erosion. In addition, wind can affect the temperature and humidity levels on the rooftop, which can impact plant growth and the comfort of gardeners and visitors.

To address these challenges, rooftop gardens may require windbreaks or protective barriers to minimize wind exposure. This can involve the use of physical barriers, such as walls or screens, as well as the selection of wind-resistant plants and irrigation systems that are designed to withstand wind (Emmanuel et al.,2016).

The orientation of the rooftop garden can also play a role in mitigating wind exposure. For example, positioning the garden behind a taller structure or on a lower level of the building can provide some protection from wind (Wong et al., 2003). In addition, the design of the rooftop garden can incorporate features that help to trap heat and moisture, such as retaining walls or raised beds (Thomaier et al., 2015) (Relf, 1992).

Ultimately, effective wind management is an important consideration in the design and maintenance of urban rooftop gardens to ensure the success of the garden and the safety and comfort of those using the space (Pfeiffer & Lohrberg, 2014).

Maintenance

The maintenance of rooftop farms can vary depending on the specific project. In some cases, the building owners or tenants may take care of the rooftop farm themselves, while in other cases, a professional maintenance team may be hired to manage the farm (Camara et al., 2021). Some urban rooftop farms may also rely on community volunteers to help with maintenance tasks (Javorek et al., 2016). The responsibilities of maintenance may include tasks such as watering plants, weeding, harvesting crops, and monitoring the health of the plants (Manzo & Devine-Wright, 2014). Generally, regular maintenance tasks for open rooftop farming may include watering, pruning, weeding, pest control, and soil management (Lipton, 2015). The frequency and intensity of these tasks may vary throughout the growing season (Sanyé-Mengual et al., 2015). Seasonal maintenance overview in Table 1. On average, a rooftop farm may require about 5-10 hours of work per week during the growing season (spring through fall) (Roofmeadow, n.d.). This includes tasks such as watering, weeding, pruning, harvesting, and general maintenance. During the winter months, the workload may decrease significantly, with some farms requiring little to no maintenance(Gianquinto & Alexander, 2017). However, this also depends on the crops being grown and the specific location. It's important to note that these estimates are based on typical small to medium-sized rooftop farms and may not apply to larger or more complex operations (Roofmeadow, n.d.). Additionally, the maintenance required for rooftop greenhouses may differ from open rooftop farms due to differences in equipment and growing conditions (NYC Parks, 2012)

Legal and regulations

There is a need for policy support and regulatory frameworks to ensure the safe and sustainable development of urban agriculture. Issues related to land use, regulations, and health risks. The chapter concludes by calling for better policies and strategies to support and promote urban agriculture, including partnerships between government, NGOs, and local communities. "To address these risks, urban agriculture policies and programs need to be designed in a way that minimizes potential negative impacts while maximizing the social, economic, and environmental benefits of urban agriculture." (p. 31) ((Mougeot, 2006)). Several countries in Europe have legislation for urban farming, including:

1. France: In 2014, France passed the "Loi d'avenir pour l'agriculture, l'alimentation et la forêt" which provides support for urban agriculture, including financial support and zoning regulations (Bockstaller, Girardin, & Van der Werf, 2017).
2. Germany: Several cities in Germany, such as Berlin, have developed policies and regulations to support urban agriculture, including provisions for community gardens and urban farming on public land (Schmutz & Jäger, 2017).
3. Belgium: The city of Brussels has implemented a "Green Network Plan" which includes provisions for urban agriculture, including the development of community gardens and rooftop gardens (Rogge & Coudron, 2019).
4. The Netherlands: The Dutch government has developed policies to support urban agriculture, including tax incentives for rooftop gardens and urban farming on vacant land (Bockstaller, Girardin, & Van der Werf, 2017).
5. The United Kingdom: Several cities in the UK, such as London and Bristol, have developed policies and regulations to support urban agriculture, including provisions for community gardens, urban farms, and rooftop gardens (Bockstaller, Girardin, & Van der Werf, 2017).

Health Concerns

There are health regulations for urban farming to ensure the safety of the produce and protect public health. The regulations can include guidelines for soil testing, water quality, pesticide use, hygiene, and food handling. The regulations can be enforced by local health departments or other government agencies (Ebisui, Hasegawa, Ohtaki, & Shiga, 2019). In many cases, the food produced in urban rooftop farms is consumed by the people who grow it, such as the building occupants or nearby residents. However, some urban rooftop farms also sell their produce to local markets, restaurants, and grocery stores (Food and Agriculture Organization of the United Nations, 2015).

Safety Concerns

Moreover, there may also be concerns related to safety, especially if access to the rooftop is not restricted or if the rooftop is not properly secured (Drury, 2017). Tenants may worry about the risk of falling or accidental injury while using the rooftop space. There may also be concerns related to liability if a tenant is injured on the rooftop or if there is damage to the building or surrounding property (Bergen, 2018).

Community Acceptance

There have been some complaints from tenants living with rooftop farming. Some concerns include noise from irrigation systems, odors from composting, and visual impacts from the farming equipment and structures (Specht, Siebert, & Hartmann, 2014). However, many rooftop farms have been successful in mitigating these concerns by implementing soundproofing measures, odor control systems, and attractive design features that blend in with the surrounding environment (Guitart, Pickering, & Byrne, 2014). Additionally, some rooftop farms have also been successful in engaging tenants in the farming process and creating a sense of community, which can help alleviate concerns and build support for the project (Bland & Gleeson, 2012). One of the concerns of tenants living with urban rooftop farms is the possibility of attracting pests. Pests such as rodents, insects, and birds may be attracted to the food and vegetation grown on the rooftop, which can lead to infestations and damage to the building and surrounding areas (Liu & Bogue, 2017). In addition, the use of pesticides to control pests can also be a concern for tenants, as they may be exposed to harmful chemicals. Proper pest management practices, such as regular monitoring, sanitation, and the use of integrated pest management techniques, can help to mitigate these concerns.

Aesthetic Concerns

One common concern regarding the community acceptance of urban agriculture is the potential alteration of the visual landscape and the perception of urban agriculture as visually unappealing or out of place within the existing urban environment (Bockstaller et al., 2017). Some individuals may find the presence of rooftop gardens, vertical farms, or community gardens to be visually disruptive or incongruent with their idea of urban aesthetics.
For example, in densely populated areas where buildings dominate the skyline, the addition of rooftop gardens or green walls may drastically change the visual character of the neighborhood. Some people may perceive these structures as detracting from the architectural harmony or altering the skyline in a way that is inconsistent with their preconceived notions of urban landscapes.

Additionally, the visual impact of urban agriculture can be influenced by factors such as the design and maintenance of the green spaces. Neglected or poorly maintained urban agriculture installations, such as abandoned or overgrown community gardens, may contribute to a negative perception of the aesthetics. However, it is important to note that urban agriculture can also enhance the visual appeal of urban areas and contribute to a sense of beauty and vitality. Well-designed rooftop gardens, vertical farms integrated into building facades, or community gardens that are thoughtfully planned and maintained can become visually attractive elements within the urban environment. These spaces can provide a refreshing contrast to concrete and asphalt, adding splashes of greenery and natural elements to the urban fabric.

Overall, the perception of urban agriculture's visual impact is subjective and can vary among individuals. While some may consider it unappealing, there are also numerous examples where urban agriculture has been embraced as a visually pleasing addition to the urban environment

1. Opposition to Community Gardens: In some cases, nearby residents or community members may resist the establishment of community gardens due to concerns over increased foot traffic, noise, or potential impacts on property values (Guitart et al., 2014). For instance, residents may express displeasure if a vacant lot in their neighborhood is converted into a community garden, perceiving it as undesirable or not aligned with their vision for the area.
2. Conflicts over Aesthetics: As mentioned earlier, there can be concerns about the visual impact of urban agriculture. For instance, individuals may find the sight of green walls, rooftop gardens, or vertical farms to be unattractive or disruptive to the existing urban landscape (Bockstaller et al., 2017). Different preferences in terms of architectural styles and urban design can influence how urban agriculture is perceived.
3. Maintenance and Management Issues: Neglected or poorly maintained urban agriculture installations, such as abandoned community gardens or unkempt green spaces, can contribute to negative perceptions. The presence of overgrown or neglected areas may be seen as an eyesore or a sign of neglect (Bockstaller et al., 2017).

It is essential to consider these viewpoints and concerns in discussions about the acceptance and implementation of urban agriculture. Addressing these issues through community engagement, effective design and management, and addressing potential conflicts can help bridge the gap and create a more inclusive and accepted urban agriculture landscape.

Conclusion

Proper design refers to the design of the building that takes into consideration the installation and maintenance of the rooftop farm. This includes ensuring that the building has sufficient load-bearing capacities to support the weight of the garden, proper water management systems, adequate lighting, and proper pest control measures. In addition, the design should consider the needs and concerns of the building's occupants, such as noise and odor mitigation, and provide for safe and secure access to the rooftop farm. Proper design can help to minimize potential problems and ensure the success of the rooftop farm. Importance of proper design for successful rooftop agriculture, including considerations such as orientation, wind, and sun exposure, and the use of appropriate irrigation systems. The authors emphasize that rooftop agriculture must be designed in a way that is compatible with the needs and expectations of the building occupants, and that addresses any potential concerns related to privacy, noise, and safety.

Challenges that building design has to take into account

1. Structural capacity: Rooftop gardens require additional load-bearing capacity, which may require significant modifications to the building's structure.

2. Water management: Proper water management is crucial to the success of rooftop gardens, which requires additional infrastructure such as rainwater harvesting and irrigation systems.
3. Lighting: Depending on the type of crops, direct sunlight is almost always necessary for healthy growth.
4. Maintenance: Rooftop gardens require regular maintenance, including watering, fertilizing, pest control, and harvesting.
5. Access: Access to the crops on any part of the building needs to be designed in order to enable can maintenance and harvesting.
6. Cost: Implementing rooftop gardens can be expensive, especially when retrofitting an existing building.
7. Legal and regulatory hurdles: Rooftop gardens require permits and approvals from local authorities, and building codes need to be modified to accommodate them.
8. Community acceptance: Some tenants have concerns about rooftop gardens, such as pests, privacy, odor, and noise, which can impact community acceptance and support for the project.

Building Design Guide for Urban Agriculture Integration

1. Site Selection:
   Consider vacant lots, rooftops, or underutilized spaces for urban agriculture installations.
   Assess the proximity to residential areas to minimize potential conflicts and address concerns regarding noise, odor, and visual impact.
   Engage with local communities and stakeholders to gain their support and input during the site selection process.

2. Aesthetics and Visual Impact:
   Incorporate architectural design elements that blend with the existing urban landscape.
   Utilize green wall systems that are visually appealing and integrate well with the building façade.
   Implement rooftop gardens that are well-maintained, aesthetically pleasing, and harmonize with the surrounding environment.

3. Noise and Odor Management:
   Implement proper design measures to mitigate noise emissions, such as using sound-absorbing materials or locating noisy activities away from residential areas.
   Employ best practices in composting and waste management to minimize potential odor issues.

4. Maintenance and Management:
   Develop comprehensive maintenance plans to ensure the regular upkeep of urban agriculture installations.
   Encourage community involvement and establish clear responsibilities for maintenance tasks.

Implement effective management strategies to prevent the abandonment or neglect of urban agriculture spaces.

5. Community Engagement and Education:
   Foster community engagement by involving local residents in the planning and decision-making processes.
   Provide educational programs and workshops to raise awareness about the benefits and importance of urban agriculture.
   Promote the sharing of knowledge and best practices among urban agriculture practitioners and the broader community.

6. Water Management:
   Incorporate rainwater harvesting systems to reduce reliance on municipal water sources and address concerns regarding water usage.
   Implement efficient irrigation systems, such as drip irrigation, to minimize water consumption and ensure precise water delivery to plants.

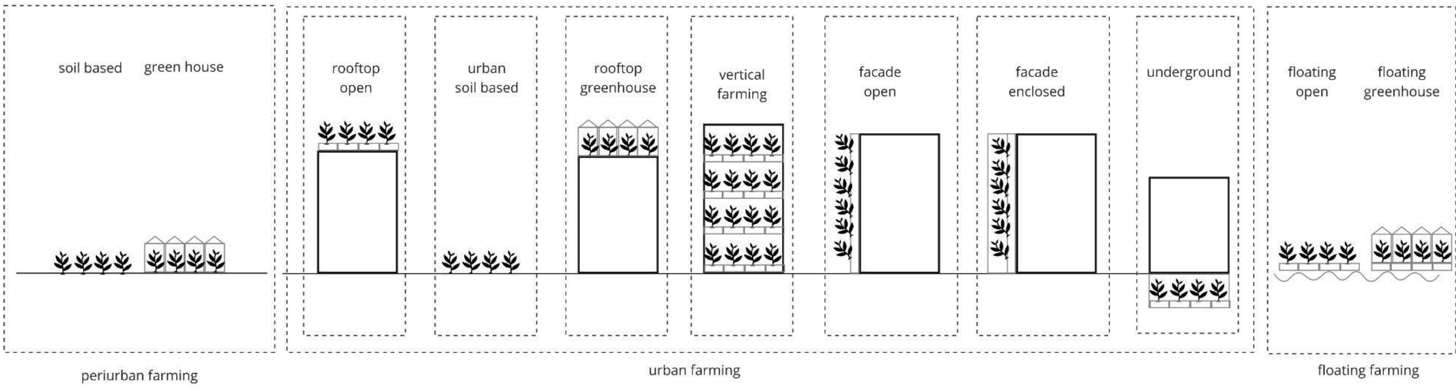
7. Consideration of Zoning and Regulations:
   Familiarize yourself with local zoning regulations and building codes related to urban agriculture.
   Ensure compliance with regulations regarding land use, structural integrity, and safety standards.

8. Ongoing Monitoring and Evaluation:
   Regularly assess the performance and impact of urban agriculture installations.
   Solicit feedback from community members and stakeholders to address any concerns or issues that arise.

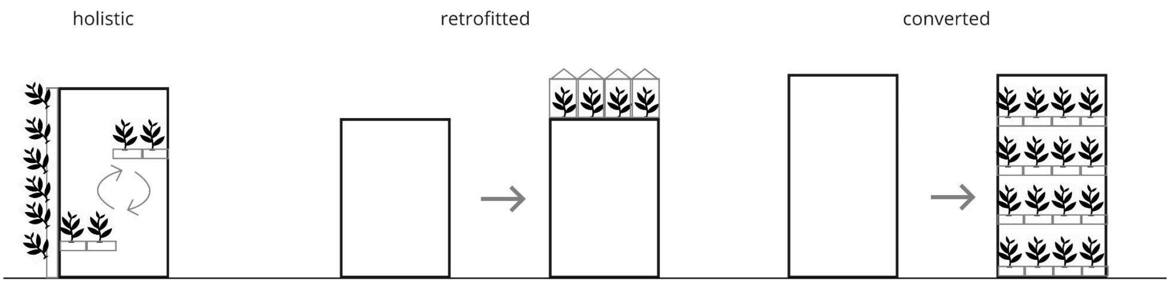
In conclusion, urban agriculture has emerged as a promising and innovative approach to address various challenges related to food security, environmental sustainability, and community well-being in urban areas. However, there are still areas that require further research and exploration to maximize the potential of urban agriculture and ensure its long-term success. The future direction of urban agriculture research should encompass a holistic approach that considers environmental, social, economic, and governance aspects. By addressing these research gaps, we can further enhance the potential of urban agriculture to contribute to sustainable and resilient cities.

Urban Agriculture systematic catalog of solutions:

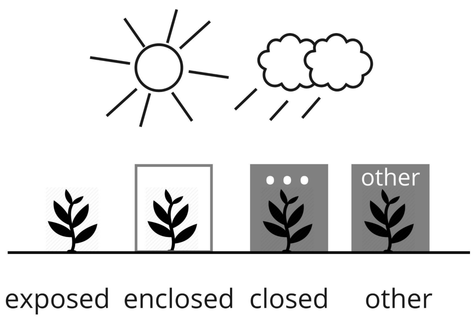
Urban Agriculture Forms



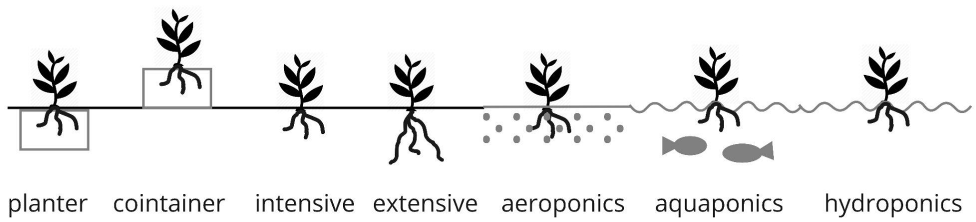
Urban Agriculture Integration Types



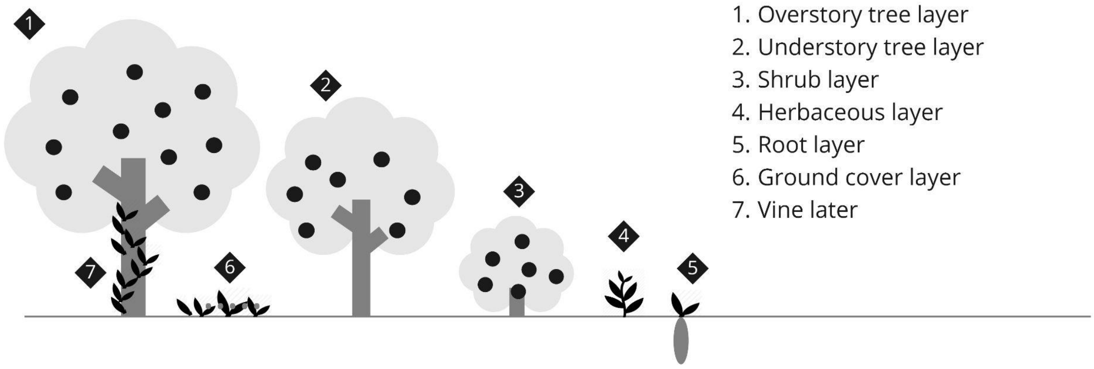
Exposure Types



Growing Medium Types



Agroforestry



Urban agriculture Load

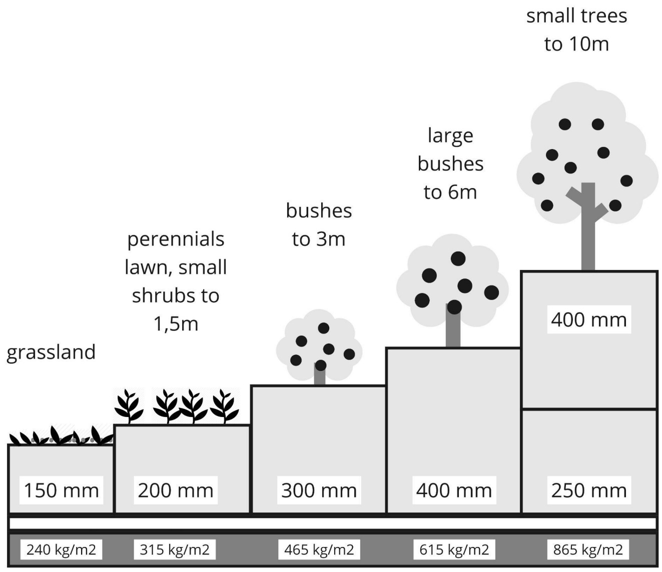


Table 1.
Seasonal maintenance of urban agriculture (Roofmeadow, n.d.) and (NYC Parks, 2012):

Spring	➢ Cleaning and preparing planting beds ➢ Starting seeds indoors ➢ Planting seedlings outdoors ➢ Installing trellises, irrigation systems, and other support ➢ Monitoring for pests and disease
Summer	➢ Watering and fertilizing plants ➢ Monitoring for pests and disease ➢ Harvesting crops ➢ Pruning and training plants as needed ➢ Monitoring for heat stress
Fall	➢ Harvesting remaining crops ➢ Cleaning up garden beds ➢ Planting cover crops to improve soil health over winter ➢ Removing and storing any trellises or other supports
Winter	➢ Monitoring the rooftop for snow and ice buildup ➢ Inspecting and repairing any damage to structures or equipment ➢ Planning for the upcoming growing season, including ordering seeds and supplies, and reviewing the previous season's successes and challenges

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