Toward Urban Agriculture Innovation: Assessing Characteristics and Limitations

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ABSTRACT

In a world where cities outgrow the food supply that sustains them, there are alternatives to intensifying or expanding already unsustainable traditional agriculture. Urban agriculture (UA) might prove to be a viable complement to the established industries, claiming many ecological and societal benefits. This paper examines the urban agriculture concept and its emergent features through a literature review, in an effort to synthesize a framework tailored to innovators. The resulting systems reveal a complex landscape of traits and constraints, and discerns four types of UA that have distinct user- and infrastructure needs.

KEYWORDS: Urban agriculture, sustainability, design thinking

1. INTRODUCTION AND BACKGROUND

More than half of the world's population lives in cities, and the number is projected to increase toward two-thirds by 2050 (UN DESA, 2018). This growth will further exacerbate the already large ecological footprint that cities account for, with current urban energy consumption amounting to 60-80 percent of the world total, and urban carbon emissions at 75 percent of the world total. (United Nations, 2018). The considerable resource demand of cities, amplified by growing urbanization and changes in citizens' consumption, is impacting the planet in myriad ways (Food and Agriculture Organization of the United Nations, 2017). But while the needs of a city may change over time, one of the key resources that cities cannot function without is nourishment to sustain its inhabitants. Food undeniably constitutes one of the most basic physiological needs of people anywhere, but cities are special in the way that they are dependent on large areas off-site and supporting infrastructures to stay efficient.

There is a case to be made for conventional agriculture's ability to cover the world's increasing nutritional demand by 2050, and to do so by increasing productivity on existing agricultural land. While this certainly would be a positive case, traditional agriculture has its share of issues, some of which will intensify as productivity increases (Food and Agriculture Organization of the United Nations, 2017). Agri-food chains already make up around 30 percent of the world's energy use and produce a fifth of global greenhouse gas emissions, making it difficult to imagine that productivity increases can be sustainably achieved without major changes. Additionally, issues relating to high-intensity cultivation of land, like water scarcity, soil degradation, overuse of fertilizer and pesticides, deforestation and loss of biodiversity will have to be overcome (Food and Agriculture Organization of the United Nations, 2017; IPCC, 2015).

Urban agriculture (UA) might hold some answers to the challenges of cities and those of traditional agriculture, and not just with regards to environmental aspects. While not a new notion – agriculture has been an integral part of cities for millennia – there seems to be a resurgence of efforts trying to reconnect urban consumers with the supply that sustains them. The past decades worth of urban densification and competition from industrial-scale agriculture has led to a marginalization of UA, but that in turn has spurred on more creative and adaptive innovations in the field, often in relation to a variety of cultural and spatial contexts (L. J. Mougeot, 2006; Soulard, Perrin, & Valette, 2017).

Urban agriculture comes in many different forms and scales. Common to them all is that they claim a wide range of benefits, some of which are increasingly supported and legitimized. Environmentally, a more local and looped agriculture practice might mean more efficient resource (re)use and waste management, whereas more control and oversight can yield higher quality produce while avoiding water and fertilizer overuse and the need for pesticides. Closer proximities may also allow for more synergy effects with the built environment, especially with established and easily accessible urban infrastructure. Bringing production closer to consumers will also diminish the need for unsustainable long-distance transport, which in turn can lead to less food loss and less need to conserve the produce. Additionally, UA can be an important contributor to carbon catching and containing air pollutants in cities, and simultaneously adjust for temperature and bouts of extreme heat and rain showers. There are also indications of UA having important ecosystem contributions, including increase of biodiversity and recovery of habitats (L. J. Pearson, Pearson, & Pearson, 2010).

Social and economic benefits of urban agriculture might be equally important arguments in discussing its potential. Foremost is its ability to conceivably aid in food security and democratization, especially for marginalized groups and the impoverished. This extends into benefits of equality, gentrification and community building, even across socioeconomic barriers. UA can also offer a recreation opportunity for urban dwellers, and even consequential public health improvements through more activity, healthier diets and benefits to mental wellbeing. UA might also give opportunity for profitable ventures and accompanying job creation, or in many cases provide important educational frameworks for research and innovation. (L. J. Pearson et al, 2010)

Despite these apparent benefits, urban agriculture remains relatively limited in its prevalence and prominence. The explanation for why that is the case is predictably complex, in accordance with the multifaceted systems of the built environment. Banking on benefits alone is simply not enough to succeed when dealing with such systems (both physical and intangible), and so the tradeoffs and constraints relating to UA might be just as important to identify and consider. By doing so, solution-oriented UA proponents might discover points of improvement and possibilities for innovation.

2. OBJECTIVE AND METHODOLOGY

2.1 Objective

The incentives for exploring the validity and potential of urban agriculture are quite pronounced, with the importance of making both our cities, consumption, and agricultural practices more sustainable being the most crucial one. While that conundrum is by no means easily solved, it also represents a potential for smaller efforts to have notable impact if successfully and widely applied. Even with the indicators that UA can provide some form of viable and sustainable complement to cities and traditional food-supply chains, it is noticeably underappreciated and often absent in official sustainability efforts. Still, institutions at the highest levels have shown increasing and visible support for UA, which might translate into mainstream legitimacy with time (L. Mougeot, 2011).

UA has been historically neglected in scholarly work on urban sustainability, as well as related fields such as city ecology and public health (L. J. Pearson et al., 2010). Pearson et al (2010) posit that this disconnect may be just as much brought on by narrow focuses in UA research as it is the narrow focus of urban planners. Increasingly though, researchers of UA appear to have broadened their scopes, and recognize the need for more comprehensive approaches delving into UA as a multi-faceted part of cities' ecosystem. At the same time they underline how innovation and more operational measures are needed in tandem with planning and visions; encouraging tangible solutions that embody the more abstract ideals of sustainability (James, 2014; L. J. Mougeot, 2005; L. J. Pearson et al., 2010)

This paper will suggest a basis for practical work with urban agriculture, catering more to designers and developers than planners and policy-makers, with the ultimate aim of inducing urban agriculture innovation. Through assessing characteristics and limitations of UA in a literature review, the paper will emphasize both context immersion and problem elaboration. This aligns with central design thinking principles (T. Brown, 2009; Buchanan, 1992), and is applicable for both ideation work and eventual innovation efforts. Firstly, the paper will review literature to systemize emergent characteristics of UA and then discern different types according to those traits and their infrastructure implications. Secondly, the primary constraints of UA will be discussed, with some reflections on design opportunities.

2.2 Definition of urban agriculture

This paper uses the term urban agriculture in accordance with the definition by Smit et al (1996, p. 1, revised 2001), as it is widely recognized and still accurate:

"an industry that produces, processes, and markets food, fuel, and other outputs, largely in response to the daily demand of consumers within a town, city, or metropolis, on many types of privately and publicly held land and water bodies found throughout intra-urban and peri-urban areas. Typically urban agriculture applies intensive production methods, frequently using and reusing natural resources and urban wastes, to yield a diverse array of land-, water-, and air-based fauna and flora, contributing to the food security, health, livelihood, and environment of the individual, household, and community."

It should be noted that related terms, such as urban farming and urban gardening, are to a varying degree overlapping with UA. The former is similar enough that this paper uses the terms interchangeably.

2.3 Methods

The reviewed literature was identified through web searches, with keywords relating to urban agriculture and farming, sustainability, consumption and supply, and city ecology. The resulting body of literature was reduced to a selection based on thematic relevance, number of citations, and topicality. The latter was especially important, as it is inextricably linked to the paper's usefulness. That stance is indicated by the majority of the source material having a publishing date within the last 15 years, with particular scrutiny of literature from before the past decade, ensuring their continuing relevance.

The results were organized and assessed, according to the incidence of either strong indications or explicit mentions of contemporary practice and its constraints. In doing so, the review covered data from both specific cases and overarching analyses, reducing the chance of missing important points.

The selected literature is predominantly covering urban agriculture in the developed world, although UA is by no means absent from the developing world. The primary purposes are often different however, with necessity driving efforts in the latter part and recreation in the former (L. J. Pearson et al., 2010). Despite the primary basis of the review being in the developed world, the findings and innovation opportunities are not exclusive, and may in fact be of special relevance for many emerging cities elsewhere.

The review also covers mainly intra-urban agriculture and rarely peri-urban agriculture (PUA). The characteristics of the two may in some cases overlap, but can be quite different and more dependent on local conditions with PUA. This is not to say that it has little to contribute. On the contrary, it might in many ways be the key to sustainable cities, bridging the rural and the urban domains and borrowing from the best aspects of both.

3. Characteristics of Urban Farming

Urban agriculture has existed for as long as cities have, but its characteristics evolve with the meanderings of technological and social development. Especially in our current times of increasingly rapid and unpredictable changes, topicality is key in understanding how to optimize UA efforts.

The following characteristics of current practices synthesized from the literature can be perceived as manifestations of environmental, societal and technological changes. While environmental trends like climate change are more broadly considered a potent influencer on food cycles, the societal and technological changes might be just as relevant, especially as urban agriculture brings producer and consumer closer together geographically and in spirit.

3.1 The importance of community values

UA efforts that have community values at the center of them are many, and the social benefit of urban agriculture can reach beyond the prospective bond and cooperation of individual farmers, and function on larger levels, even city-wide. In many cases UA can offer solidarity across barriers of socioeconomic status, ethnicity and gender, facilitating equality and strengthening community cohesion (Deelstra & Girardet, 2000).

Cities have advantageous conditions for UA networks, simply by having many people collocated with easy access to necessary infrastructure. Such networks of trading and sharing knowledge, tools and goods, are important components in a connected society of urban farmers, and are crucial for the initiation of novice urban farmers and hobbyists (Thomaier et al., 2015).

The UA efforts that are community-centric appear to be more resilient and long-lasting than those that are not. It seems to be related to the shared responsibility and negotiation capacity, the abovementioned sharing networks, and a beneficial sense of ownership, resulting in more long-term thinking (K. H. Brown & Jameton, 2000). Having access to community knowledge and manpower proves useful beyond successful production, for example through mitigation against trespassing and vandalism (Zasada, 2011).

The extension of clever cooperative investment into UA can be found in the principles of community-supported agriculture (CSA), where consumers buy shares in a harvest in advance (Zsolnai & Podmaniczky, 2010). Often, the consumers can influence the type of produce and do voluntary work, forming close-knit producer/consumer communities (Soulard et al., 2017; Zsolnai & Podmaniczky, 2010). These features indicate that UA has favorable conditions for CSA-type arrangements.

3.2 Space efficient solutions

Many urban agriculture initiatives are focused on maximizing efficiency in the often limited spaces they occupy, which in practice necessitates using space more efficiently or intensifying production. One way of achieving the latter can be to strategically select what is grown to maximize output and profit. This can be optimized according to nutritional value, growth cycles, or public demand. The advent of genetically modified organisms (GMO's) may in time push the limits further, and possibly contribute to making UA viable, but it is at present time not embraced by the public due to valid concerns for the consequences (Despommier, 2011; Food and Agriculture Organization of the United Nations, 2017).

Significant efforts aligned with space efficient principles are projects utilizing spaces in or on the built environment (zero-acreage farming), requiring no other urban land areas, which often are contested or strictly regulated (Thomaier et al., 2015). Such projects constitute a large part of the UA stock, and are especially interesting in that they can endure densification and a competitive real-estate market.

A subset that pushes space efficiency closer to extremes is found in vertical farming projects. Fully embracing the available three-dimensional volumes endemic to cities, these projects are often technologically advanced and optimized for maximum output, predominantly for commercial purposes (Al-Chalabi, 2015; Despommier, 2011). Vertical farming is considered promising by many advocates, but skepticism remains as the resource requirements increase with the intensity of production.

A way for UA to assert its place in the cityscape, might be through integrated, multi-use concepts. Wilson (2007) highlights the implicit connections between mixed-use agriculture and the emergence of multifunctional urban planning. Many UA initiatives are in accordance with this, useful to validate their existence and use of space, with ancillary contributions to city form and function. The urban form is also speckled with spaces that are vacant, in the margins, or has other primary purposes. This can benefit resourceful urban farmers, especially in cities with restricted rights or regulations (Galt, Gray, & Hurley, 2014; McClintock, 2010).

3.3 Controlled environments

Urban agriculture in its different forms are all carried out in environments that are regularly controlled, a result of the mere proximity and organization of urban productive spaces. In practice that can be everything from highly technical and physically contained variants, to more communal setups with shared oversight.

Controlled-environment agriculture (CEA) is an approach that specifically attempts to optimize resource use, usually within an enclosed space (Despommier, 2011). These ideals are to a varying degree implemented in practice, but are emerging as potent argumentation for major shifts in agriculture, both rural and urban (C. J. Pearson, 2007). Other important features are CEA's aim to be regenerative in nature, recycling productive waste and energy, and its diminishing need for fertilizers and pesticides (Deelstra & Girardet, 2000; Despommier, 2011; C. J. Pearson, 2007).

Ways of exacting control over growing environments are facilitated by the development and accessibility of ICT. This largely applies to sensors and surveillance technology, allowing for increased security and stability, not to mention the creation and analysis of data for optimal conditions (Sivamani, Bae, & Cho, 2013). The extension of optimization may be through automating the processes (Despommier, 2013), but such efforts remain in their infancy.

3.4 Symbolic value

Urban agriculture of today can be characterized as a way of showcasing commitment to sustainable ideals. For businesses it can both constitute cheap and sustainable supply, and perhaps more importantly offer favorable optics and promotional opportunities. For individuals or groups, UA can emerge as a resurgence of valuing self-sufficiency, or simply as a way of expressing identity.

The produce of UA can have favorable properties, which is an important factor in consumers' willingness to pay, or to do voluntary work. Central are the health benefits of the varied and nutritious diet that follows the greener output often associated with UA. Production is also often organic and pesticide-free, which attracts further proponents.

Symbolism found in the environmental benefits can be equally compelling, as the public awareness and interest in sustainable food practices increases. The origin of consumers' food, and where the waste ends up, are elements of the public discourse that UA in many ways can answer (Deelstra & Girardet, 2000), being locally sourced almost by definition.

3.5 Empowered producers & consumers

Urban agriculture can in many cases offer individuals or groups some semblance of control of their own consumption cycles. Historically, it has proved vital in times of crisis or conflict, but is also relevant in times of a public with distrust of governments and the agriculture industry (Galt et al., 2014).

Decentralization of food-supply chains can also benefit societies regardless of ideology; it increases resilience against natural disasters and is a risk reducer in the face of interference from malicious actors. Conventional agriculture is more prone to be affected by such unforeseen events and affects many once they occur, but a decentralized, more widely adopted UA system may empower producer and consumer alike.

Some argue that UA might be a democratization contribution (Grewal & Grewal, 2012), through poverty alleviation and independence from third-party industries that are not always transparent in their practices. The lower threshold for initiating UA is inclusive, especially in terms of easy access to information and cheap resources, although other limitations make complete self-sufficiency a faint prospect. UA can however help in freeing up monetary assets for other uses, such as education (Badami & Ramankutty, 2015; K. H. Brown & Jameton, 2000; L. J. Mougeot, 2006).

4. Urban Farming Typology

The paper proposes the following typology as a way of contextualizing the traits, attempting to identify a tangible basis for design opportunities. There might be different strategic orientations and variations of governance within each type, but the user- and infrastructure needs are largely different.

4.1 Fringe farming

Interstitial and multi-use spaces on the margins of the built environment are used for food production and guerilla gardening initiatives. Ownership is substituted for sharing, and projects require little or no supporting infrastructure or oversight.

4.2 Community-centric UA

Parcel and allotment gardens, community gardens, and school gardens, are important social contributors to neighborhoods and urban communities. Risk, responsibility, knowledge, goods and tools are shared.

4.3 Private and small-scale commercial UA

Small-scale efforts in private homes and gardens. Limited produce, but significant symbolic value and sometimes commercially viable. Typically in the vicinity and often inside the site of consumption.

4.4 Large-scale commercial UA

Industrial scale agriculture within the bounds of the urban perimeter. Demanding in many respects, needs systematic oversight and planning to succeed. The most demanding type in terms of resources and infrastructure.

5. Urban Agriculture Constraints

To find solutions that are effective and long-lasting, innovators will benefit from a clearly defined problem. In the case of urban farming, this paper proposes that it can be achieved by identifying the most prominent limitations it has as a credible contributor to the urban consumption. Through assessing the constraints found in the literature, a system is synthesized, however it should be noted that the resulting list isn’t quantified and isn’t ordered. For that, further research is required, with concrete and quantifiable data delving into each aspect.

The constraints identified will rarely incumber UA in isolation, but for the purposes of the following section they will be addressed as such. Their central features will be covered, and they will be viewed in a more critical perspective that affords innovation opportunities.

5.1 Area constraints

Constraints of available area represent perhaps the most obvious limitation of urban agriculture. This issue relates closely to regulations, competition and cost of land (discussed below), but mainly concerns the real physical limitation of the built environment.

Area constraints are not just an issue of many concrete projects, it is also an overarching existential question for UA, and whether it can realistically contribute to food security. Analyses indicate that the global urban area is larger than the global harvest area for vegetables, though far less in size than the area used for producing cereals. While the possibility of covering urban vegetable needs is encouraging, the numbers show how the potential is limited, although not accounting for more optimistic vertical farming scenarios (Martellozzo et al., 2014). Badami & Ramankutty (2015) further assessed UA's ability to realistically increase food security (focusing mainly on the urban poor), finding that in high-income countries it could be feasible (while largely ineffective), but with low potenital in the low-income countries where it would be the most helpful. The paper however underlines the other benefits of UA and the role it may play in urban food systems.

Many initiatives like the ones inventoried by Thomaier et al. (2015) focus on answering the area problems of dense urban environments, but are comparatively negligible in output to traditional agriculture, no matter how integrated and efficient the space utilization is. And using volume to maximize area efficiency, the basic tenet of vertical farming concepts, quickly runs into problems of energy demand. Coming to terms with cities apparent inability to realistically sustain its own consumption totally, proponents should embrace the considerable benefits of smaller contributions, which in sum may cover production of important food segments, such as fresh produce (Grewal & Grewal, 2012).

Utilizing areas that are derelict or have other primary uses, like vacant lots, interstitial areas and parks, might be a natural progression for expanding UA. These are already used for farming in many cities, but may conceivably facilitate more temporary setups, adaptive and movable, albeit with a considerable dependence on government support and leniency. With facilitation though, such a category could also include temporary or seasonal UA use of other areas, such as parking spaces, sidewalks or city squares.

5.2 Energy demands

In the many cases that urban agriculture can claim superior productivity to the alternative, the energy demands are often high, with optimized operations requiring electricity for lighting, heating/cooling, or water pumps. In fact, looking at the extreme cases of vertical farming, the energy demand can lead to larger carbon footprints than conventional agriculture, although that will not be the case if renewable energy is used or produced on site (Al-Chalabi, 2015; Despommier, 2011).

This tradeoff of energy use and output is not just an issue for highly technical concepts, it may also be relevant in challenging climates where controlled environments or prolonged growing seasons are desirable (Despommier, 2011). On the other hand, the need for energy doesn't always entail a large carbon footprint. Abundance of cheap and renewable energy might be vital to construct viable concepts, or even favorable local conditions such as abundance of sunlight or a temperate climate.

A valid way of reducing energy demand of UA might be to locate production where there are useful waste products, for instance waste heat from buildings or industry can contribute to lowering (or altogether eliminating) heating costs, or lower-scale systems may utilize light primarily meant for other purposes (Thomaier et al., 2015; Van Veenhuizen, 2014). Another possibility is to explore favoring crops that more efficiently convert energy to nutrition, or even genetically modifying organisms to respond to certain light frequencies.

5.3 Water and fertilizer demands

Even though some initiatives are designed to use much less water, many forms of UA need constant water supply for irrigation. The accessibility of such a precious resource in cities is at times limited, with many cities already dealing with water crises with current use alone.

The reuse of wastewater for agricultural purposes is shown to be a possible mitigation strategy, although such recycling is not without issues in itself, mainly through risk of contamination and pollution (Deelstra & Girardet, 2000; L. J.

Mougeot, 2006). Collection of rainwater is another proven way of meeting urban water demands (L. J. Mougeot, 2006; Thomaier et al., 2015), without hazardous side-effects, although also without the nutrient potential of wastewater.

Similarly to water, most versions of UA cannot function without some sort of fertilizer supply. Synthetic options require emission-heavy off-site production (Food and Agriculture Organization of the United Nations, 2017), but cities fortunately produce plenty of organic waste. Utilizing this waste, including human and animal feces, yields the possibility of covering the fertilizer demands of UA, but only if overcoming taboos and possible health risks (McClintock, 2010; Soulard et al., 2017).

5.4 Competition

Urban agriculture is often on the losing side with efforts of densification, as green spaces of all descriptions are marginalized. Even in cities where greenstructures are much considered, there is 'internal' competition over the different functions of the green areas (Hanssen, Hofstad, & Saglie, 2015).

These competing interests grow more prominent in ever denser compact cities, in which people treasure outside areas for recreation, and also desire access to day-/sunlight, which is not always in abundance. Citizens might prove to prefer having productive areas at a distance and outside city limits, if the alternative is an imposing presence on their surroundings (through noise, smells, or dust) (L. J. Pearson et al., 2010)

Commercial UA will rarely be able to compete with conventional agriculture on price, and is reliant on consumers favoring locally produced, fresh produce (Thomaier et al., 2015). Even trying to achieve self-sufficiency might be difficult, if facing cheap and easily accessible industrial food from linear food supply chains. Aggressive competition and lobbying to limit UA might not be a probable issue at this point in time, although the urban agriculture sector might be more of an economic challenger as it grows in scale and commercialization.

If the harvest and transportation phases of conventional agriculture can become totally fossil-free, as well as having a more space efficient and environmentally controlled overall practice, then the thesis of large-scale UA might be increasingly irrelevant, shifting focus toward benefits other than environmental ones.

5.5 Planning and regulations

Many cities are already encouraging UA, though some may simply do so formally with little tangible support. The myriad indirect benefits of UA, such as public health and social improvement, might however encourage policy-makers to make real efforts and take lead in the research development (Deelstra & Girardet, 2000).

The restraint is understandable in the face of questions of productivity and energy efficiency, requiring more research to be sufficiently answered. Mougeot (2006) proposed some measures for the consideration of city officials and -planners, focusing mainly on empowering urban farmers and equalizing opportunities for marginalized groups. Five years later, the author revealed a string of promising trends, notably a distinct rise in government engagement and shifts in research approaches (L. Mougeot, 2011).

Struggles with shaping urban policy to best aid urban agriculture projects remain, with political support not necessarily translating to practical implications (L. J. Pearson et al., 2010). A workable approach may be to allow for more flexible and temporary solutions, encouraging more organic prototyping approaches to city development.

5.6 Financing

The costs of UA vary a lot from near zero to funding large industrial enterprises. Financing does however emerge as a key challenge once the scale goes above the hobbyist level, especially for funding new initiatives (Thomaier et al., 2015). And in the case of vertical farming, costs are one of the deciding factors in choosing whether whole new structures are needed or if designs can be retrofitted (Al-Chalabi, 2015).

Funding is ultimately sourced through a patchwork of investors, grants and variations of crowdfunding (Thomaier et al., 2015). Although such investment costs can be considerable, there is also a potential of UA being profitable when commercialized, at the very least as a secondary or tertiary income (Thomaier et al., 2015; Van Veenhuizen, 2014).

The strong implicit link between UA and some level of food security, somewhat eclipses the fact that production might yield produce other than food. Other uses might be relevant, especially in developing possible business models for UA. They can plausibly center around biotreatment of organic waste for fuel or fertilizer, producing materials, or even pharmaceuticals.

The practices of UA can also be extended beyond its obvious applications. It represents a more cyclic and often efficient way of growing food, making it applicable beyond the scope of the cityscape; to offer food security in extreme climates, like deserts and polar regions; far off places, like offshore or at research stations; or even in the very extremes of human settlement, like in space or potential off-world settlements.

5.7 Dissemination and distribution

Connecting producers with consumers or other contributors is important for commercial efforts, sharing knowledge and goods, and for building urban farming communities (Thomaier et al., 2015). Although the communication infrastructure is in place, limitations through lack of knowledge raises the threshold for inclusion and initiatives.

The lack of knowledge spans from individuals to the governmental level, leading to a reliance on public opinion that can be skeptical and at times divorced from facts. An example of a such social barriers is in the impression that food grown in more controlled environments with hydroponics is in some ways synthetic, unnatural and more chemical (Al-Chalabi, 2015). The contrasting reality is that it may produce more stable crops resulting in nutritious food, satisfied consumers and consequentially less food waste.

The current landscape of information and communication technologies offers the right circumstances and timing for introducing networks of dissemination and distribution. In the age of social media and ecommerce especially, platforms to share knowledge, trade, and showcase opportunities can be instrumental in UA innovation efforts.

6. Conclusion

The data relating to urbanization, climate change, and unsustainable agricultural practices, indicate an urgency to find solutions that in sum may contribute to sustainability goals. By reviewing the relevant literature, the characteristics and limitations have been assessed and systemized, with a further suggestion of a typology to exemplify UA in practice.

For innovators, the main findings to note is UA’s interrelatedness with the complexity of the urban form and functions, as well as how it evolves with technological and societal change. Further, the typology suggests that the most practical way of structuring UA is according to user- and infrastructure needs. And notably, that UA constraints like financing, competition and underdeveloped information infrastructure can be equally constraining as resource demand or spatial limits.

The implications for designers and developers are that there is never just one constraint to overcome, and that taking all limitations into account is to be recommended when working with UA. In embracing complexity and more operational approaches, while concurrently understanding the users of our cities’ spaces and services, future urban agriculture solutions can be carefully and sustainably provided. We may never cover all the needs of a city from within its urban boundaries, but every step towards self-reliance and sustainability is sure to benefit its citizens.

REFERENCES

Al-Chalabi, M. (2015). Vertical farming: Skyscraper sustainability? Sustainable Cities and Society, 18, 74-77.

Badami, M. G., & Ramankutty, N. (2015). Urban agriculture and food security: A critique based on an assessment of urban land constraints. Global Food Security, 4, 8-15.

Brown, K. H., & Jameton, A. L. (2000). Public health implications of urban agriculture. Journal of public health policy, 21(1), 20-39.

Brown, T. (2009). Change by design.

Buchanan, R. (1992). Wicked problems in design thinking. Design issues, 8(2), 5-21.

Deelstra, T., & Girardet, H. (2000). Urban agriculture and sustainable cities. Bakker N., Dubbeling M., Gündel S., Sabel-Koshella U., de Zeeuw H. Growing cities, growing food. Urban agriculture on the policy agenda. Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft (ZEL), 43-66.

Despommier, D. (2011). The vertical farm: controlled environment agriculture carried out in tall buildings would create greater food safety and security for large urban populations. Journal für Verbraucherschutz und Lebensmittelsicherheit, 6(2), 233-236.

Despommier, D. (2013). Farming up the city: the rise of urban vertical farms. Trends in biotechnology, 31(7), 388-389.

Food and Agriculture Organization of the United Nations. (2017). The Future of Food and Agriculture. Trends and Challenges. Retrieved from

Galt, R. E., Gray, L. C., & Hurley, P. (2014). Subversive and interstitial food spaces: transforming selves, societies, and society–environment relations through urban agriculture and foraging. In: Taylor & Francis.

Grewal, S. S., & Grewal, P. S. (2012). Can cities become self-reliant in food? Cities, 29(1), 1-11.

Hanssen, G. S., Hofstad, H., & Saglie, I.-L. (2015). Kompakt byutvikling: muligheter og utfordringer: Universitetsforl.

Intergovernmental Panel on Climate Change. (2015). Climate change 2014: Mitigation of climate change (Vol. 3): Cambridge University Press.

James, P. (2014). Urban sustainability in theory and practice: circles of sustainability: Routledge.

Martellozzo, F., Landry, J., Plouffe, D., Seufert, V., Rowhani, P., & Ramankutty, N. (2014). Urban agriculture: a global analysis of the space constraint to meet urban vegetable demand. Environmental Research Letters, 9(6), 064025.

McClintock, N. (2010). Why farm the city? Theorizing urban agriculture through a lens of metabolic rift. Cambridge Journal of regions, economy and society, 3(2), 191-207.

Mougeot, L. (2011). International Support to Research and Policy on Urban Agriculture (1996-2010): achievements and challenges. Urban Agriculture Magazine, 25, 2012-2017.

Mougeot, L. J. (2005). Agropolis: The social, political, and environmental dimensions of urban agriculture: IDRC.

Mougeot, L. J. (2006). Growing better cities: Urban agriculture for sustainable development: IDRC.

Pearson, C. J. (2007). Regenerative, semiclosed systems: a priority for twenty-first-century agriculture. AIBS Bulletin, 57(5), 409-418.

Pearson, L. J., Pearson, L., & Pearson, C. J. (2010). Sustainable urban agriculture: stocktake and opportunities. International journal of agricultural sustainability, 8(1-2), 7-19.

Sivamani, S., Bae, N., & Cho, Y. (2013). A smart service model based on ubiquitous sensor networks using vertical farm ontology. International Journal of Distributed Sensor Networks, 9(12), 161495.

Smit, J., Nasr, J., & Ratta, A. (1996). Urban agriculture: food, jobs and sustainable cities. New York, USA, 2, 35-37.

Soulard, C.-T., Perrin, C., & Valette, E. (2017). Toward sustainable relations between agriculture and the city: Springer.

Thomaier, S., Specht, K., Henckel, D., Dierich, A., Siebert, R., Freisinger, U. B., & Sawicka, M. (2015). Farming in and on urban buildings: Present practice and specific novelties of Zero-Acreage Farming (ZFarming). Renewable Agriculture and Food Systems, 30(1), 43-54.

United Nations. (2018). Sustainable Development Goal 11 - Sustainable Cities: Why they matter.

United Nations Department of Economic and Social Affairs. (2018). World Urbanization Prospects: the 2018 Revision - Key Facts.

Van Veenhuizen, R. (2014). Cities farming for the future: Urban agriculture for green and productive cities: IDRC.

Wilson, G. A. (2007). Multifunctional agriculture: a transition theory perspective: Cabi.

Zasada, I. (2011). Multifunctional peri-urban agriculture—A review of societal demands and the provision of goods and services by farming. Land use policy, 28(4), 639-648.

Zsolnai, L., & Podmaniczky, L. (2010). Community-supported agriculture: na.