Hanging Gardens of Babylon: Reframing Urban Agriculture as an Opportunity for Social Engagement

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Abstract

Urban agriculture is seen as an opportunity to co-locate food production with the 80% of the world's population living in cities, decrease costs of transporting produce, and improve the self-sustainability of cities. However, there has been much debate on the effectiveness of this strategy. Urban farms typically make less efficient use of input resources, have less potential for high output, and often fail to benefit the most food-insecure and marginalized urban residents. Despite this, the numerous successful urban gardening projects and urban green spaces in recent years point toward a continued demand for these systems, suggesting other reasons for their appeal. We aim to re-frame the perceived benefits of urban green spaces and urban gardens as social, emotional, communal, environmental, and aesthetic as well as productive. With these goals in mind, urban gardens and green spaces can be optimized not simply for feeding urban communities but for connecting and educating them. In this paper we discuss how the advent of low-power autonomous farms are an opportunity to scale urban gardens to a city-wide adoption. Furthermore, we propose that social computing applications and novel interaction can be leveraged to broaden engagement with urban gardens at varying levels among diverse populations.

Author Keywords

Urban Gardens, Urban Agriculture, Interaction Design, Autonomous Agriculture, Social Networks, Community Engagement

CCS Concepts

•**Human-centered computing** $\rightarrow$ **Interaction Design;** *Ubiquitous and Mobile Computing;* **Human computer interaction (HCI);**

Introduction

Urban gardens can enrich underdeveloped urban spaces such as rooftops and overpasses that would otherwise contribute to the well-documented urban heat island (UHI) effect, where absorbent materials that make up urban environments trap heat from cars, buildings, sunlight, and people[7]. Projects like the New York High Line which successfully converted a retired overpass into a thriving urban parkway can revitalize cities and connect pedestrian traffic between neighborhoods. While this success is one 153 million dollar architectural example, a city densely covered in urban gardens could be just as inviting, with marginal cost to the owner. The main barrier to this wide-spread adoption is the exclusivity of the existing urban agriculture community and the inaccessibility of urban gardening to non-agriculturally minded residents due to the expertise and time required to install and maintain these spaces.

Urban residents live fast-paced lifestyles, and tend towards significantly shorter housing tenure as compared to suburban or rural residents. This means renters have less stake in their residence than a rural homeowner and are less likely to invest in the building they occupy [11], but landlords don't have as much intrinsic motivation to manage something as high maintenance as a rooftop garden. We claim that urban gardens could be treated more as a building component or basic utility (like an HVAC system or home refrigerator) than as a separate commodity that renters must buy and install themselves. Autonomous gardening systems could maintain these ubiquitous urban gardens, and simplify the complex sharing of responsibilities between tenants and landlords.

We envision a future where current developments in autonomous low-power gardening systems are commercialized and deployed in cities at scale. With a critical mass of urban gardens, interaction systems could be designed to inform other residents about the existence of these gardens and their produce. This could lead to a network of urban growers and establish an active subculture and associated economy grounded in a sustainable practice.

However, while these autonomous systems reduce the expertise required to manage an urban garden or farm, they do not broaden the awareness and use of these gardens by local residents. Urban gardens often suffer from low community engagement (causing them to fall into disrepair), and also tend to attract an audience of—typically affluent and white—non-residents as opposed to those co-located within the neighborhood [6, 17]. We believe well-designed interaction systems that leverage the affordances of ubiquitous urban gardens and require little to no effort from the end user can improve awareness of and access to fresh produce and make urban gardens a powerful urban development. These systems could network between sensor-equipped gardens and provide an interface between gardeners and consumers. They would tackle low user-ship of urban gardens and low diversity of user body by disseminating information to the public in multiple tiers, and also provide a persistent data layer to allow city planners to observe their impacts and track neighborhood activity. In this paper we present goals, features, and potential interactions for these systems.

Background

In this section we outline the existing research both for and against urban agriculture to convey a clear history of the literature and existing technology.

Debate on Urban Agriculture Efficiency

Many proponents argue that urban gardens could reduce or remove the delivery costs of fresh produce. One study found that most traditionally grown produce travels anywhere between 700 and 2000 miles to reach terminal markets in Chicago [15]. However, a 2008 study at Carnegie Mellon found that an overwhelming 83% of all greenhouse gas (GHG) emissions produced by agriculture are due to the food production itself, while only 4% of the GHG emissions are due to last-mile transit. The study concludes that switching to a plant-based diet–even as minute a change as forgoing meat for one day a week–can have substantial impacts on climate change that outweigh those of moving agriculture to the consumer [20].

Other studies concur that transportation emissions overall make up a small fraction of farming-related GHGs [1, 10], but this fraction becomes larger for produce transported by air such as berries [10]. One future interaction system could inform urban gardeners (and consumers) of emission costs of specific produce to allow them to optimize for growing or consuming produce to reduce high carbon costs for transit.

Another study found that reduced transit emissions due to urban farming could be outweighed by scaled urban farms' potential to increase urban sprawl [14]. Furthermore, poorly-planned urban farms could use water, fertilizers, and pesticides less efficiently than rural farms [4]. However, another study found that, if resources are managed judiciously, urban gardens can be twice as productive as their rural counterparts [13]. These findings argue for well constrained urban farm design. An entirely self-sufficient garden could run on grey-water. storm-water, urban compost, solar power, and be built on difficult to use space. On the other hand, rural agriculture still requires large subsidizes to be profitable, and the bulk of rural agriculture produces monoculture feed-crops for livestock rather than produce. Distributed urban produce gardens could become a viable sustainable alternative, despite inefficiencies.

Urban Agriculture vs. Food Insecurity

Food insecurity is still rife in under-served areas; 2.3 million people live in low-income rural areas more than 10 miles from a supermarket [19]. But this problem is complex and multifaceted, not solvable via access alone. Even those with access to supermarkets within a 10 mile radius may not have adequate nutrition awareness, habits, or budget to make healthy dietary decisions. Residents of the poorest areas have 2.5 times as much exposure to fast-food restaurants as those living in wealthier areas [23]. Therefore, a combination of nutritional education and affordable, convenient access to produce could disproportionately benefit those in under-served areas. This positions accessible and socially integrated urban gardens as a strong social and educational tool for under-served neighborhoods with potential to catalyze a market for healthier options, instead of the typically unhealthy goods that characterize food deserts.

Health and Social Benefits of Urban Green Spaces

A 2016 study concluded that while urban agriculture may not be able to solve food insecurity, it can have a large impact on social capital, community well-being, and civil engagement in the food system [16]. Exposure to urban green space has been linked to an array of health benefits including reduced heart rate and cortisol concentration, improved mood, stronger attention, increased physical activity, and reduced violence [9]. Urban gardens serve as a primary destination for city residents over 55 [3], a demographic group likely to be heavily constrained in their ability to travel to distant food sources. Another study found that the psychological restorative benefits of green spaces were shared equally among all age groups, genders, and ethical backgrounds and that the more botanically diverse the green space, the stronger were the psychological restorative effects. This suggests that a diverse array of urban gardens coordinated to grow unique, complementary plants and produce could have better psychological benefits than standard parks [22]. Rather than creating urban sprawl, diverse urban gardens could be designed as social corridors connecting neighborhoods or mapping high-traffic walking paths to improve city life.

Environmental Side-effects of Urban Green Spaces
Urban gardens and green spaces also provide an array of direct and indirect environmental and ecological benefits for cities. Granular air pollution is becoming an increasingly troubling metric in urban spaces and can vary drastically from street to street. With a map of air pollution in cities, urban green spaces and rooftop gardens can be deployed in targeted areas to filter polluted air at a granular scale [5]. Urban green spaces can also help cool down cities, retain precipitation, prevent storm-water runoff, and even provide habitats for species that rely on particular vegetation, such as bees and certain butterflies, whose habitats are traditionally threatened by urban expansion [12, 21]. Furthermore, exposing urban residents to the food system can reveal how much work goes into growing food, and indirectly lead to less wasteful behaviors and more sustainable choices [2].

We also propose that urban gardens become hyper-local endpoints for compost produced by co-located residents and restaurants to reduce GHG emissions from transit. Finally, highly visible and socially integrated agriculture systems could draw attention to the convenience and cost-effectiveness of plant-based diets, divert residents away from the unsustainable fast-food market, and motivate improved municipal grey-water and compost systems.

Advances in Agricultural Technology and Automation

FarmBot
FarmBot is an open-source computer numerical control (CNC)-style autonomous farm device leveraging a 3-axis slider to perform almost all mechanical processes for growing produce including sowing, watering, and weed control. Open-source, extensible, and deployable at scale on small plots, it can be implemented fully off-grid, sourcing solar power and collected storm-water. While it has an associated user interface application, it does not support connectivity, a social platform, or community outreach for growers. Residents often resort to Facebook groups to build community with other urban agriculture participants.

Square Roots
In 2016, the company Square Roots began an effort to bring vertical hydroponic gardening to urban areas by outfitting unused shipping containers with hydroponic equipment, forming modular and portable urban gardens. While these containers can produce large quantities of produce, they require a high cost, level of expertise, and space for installation and maintenance.

FarmBeats
FarmBeats is an internet-of-things (IoT) driven low-power autonomous farm monitoring system [18]. This complex yet low-power sensing solution leverages solar-powered drones, sailing-inspired aerodynamic flight patterns, and TV whitespaces for networking to achieve energy savings. While this system can improve farm monitoring, it is de-

signed for large rural farms rather than small plots, which can be better monitored using soil sensors.

Shared Earth
Shared Earth is an online platform to connect residents with available yard space or gardening tools with those interested in cultivating land. While yard-sharing can allow connections between already agriculturally-minded people, it remains small and relatively obscure due to a lack of interaction with the broader public, who may not have resources or expertise but could want access to fresh produce.

Applications and Design Guidelines

In this section we propose design guidelines for a system that addresses the aforementioned challenges, outlining three distinct phases for goals and proposing three example modalities for user interactions.

Goals

1. Enroll new users of urban gardens previously unfamiliar with or unaware of them;
2. Retain engagement of existing users in a way that requires little to no planning for the end user and is personalized; and
3. Support extreme interest and involvement of major actors in the system, analogous to moderators on online forums who are more invested than typical users.

Potential Interactions

1. Observing mounted indicators visible from public streets showing the existence and progress of crops' development on/in local buildings, with associated QR codes or other linkers to mobile applications;
2. Subscription and notification through mobile app-based systems of neighborhood users to specific crops from any nearby garden, or any crops from a specific garden; and
3. Use of city-wide maps of gardens and their respective produce, viewable through a web client or mobile app, to support urban foragers, specific beneficiaries such as homeless shelters, or heavily engaged urban farmers.

Combining these interactions allows for a broad degree of potential engagement with the urban food system along a continuum of interests. Users can simply accept local surplus, or form foraging groups to traverse the city, gathering excess produce to stock community kitchens. The key design vision of this system is that the interface between residents and urban gardens should not be dependent on expertise or previous personal connections. Interactions should both support the engagement of new actors and remain valuable to the very experienced.

We highlight Interaction 3 as particularly useful as a foundation for future advances, such as optimizing the types of produce to be grown in each garden as a function of biodiversity with respect to neighboring gardens. Future cities may be able to algorithmically determine which crops to grow in gardens to maximize local access to a diversity of produce, reducing the probability that food may go unused due to surplus.

Future Urban Gardening Systems

This section briefly discusses the physical media that could host future urban gardens and green spaces, as well as future social platforms that can be built on top of them.

Opportunities for Urban Garden Installation
Urban gardens could occur in almost any flat space within city limits, horizontal or vertical. For example, vertical farms could be installed along the sides of buildings. Unused plots of lane, residential and commercial roof space, and unused sidewalk areas make for clear initial choices. An example of more complex urban farms could be arable high-rises similar to those of the Sunqiao District in Shanghai designed and proposed by Sasaki. Agricultural plots under development could be built up story by story like building frames, designed to house stacked urban farms or large greenhouses. Sasaki has proposed this type of urban garden as a way to simultaneously attract pedestrian traffic, manage air quality, improve urban aesthetics, and grow produce.

Another ambitious agricultural installation could be green awnings that make use of small-scale roof space above building entryways. The small, raised nature of these spaces could make them optimal for hanging vine produce that would otherwise require trellises or supports.

Mobile gardens could be a potential solution in instances of rapidly developing cities with changing landscapes. A garden box on wheels could be moved between plots as new infrastructure fills in spaces, until a permanent home is found. This would allow local residents or urban planners to make quick or transient use of space. By temporarily occupying spaces before development projects start, these gardens could lower instances of property crime [8].

Opportunities for Urban Garden Social Platforms
We envision social computing platforms that will be critical in supporting residents' engagement with ubiquitous urban gardens on city-wide scales, and provide both real and speculative examples of such systems.

In 2008, the Boston iNaturalist City Nature Challenge asked locals to crowdsource a dataset documenting all species of plants, animals, fungi, and more observed in the city of Boston along with location coordinates for a visualization. A similar mapping system called Falling Fruit, run as a 501(c)(3) non-profit, leverages a combination of web-scraping and crowdsourcing to maintain a worldwide map of over 1,436,968 locations of 2,685 different species of edible plants and fungi. While this maps many potential urban foraging locations, it does not incorporate any recruitment or interface with non-foragers, making the system inaccessible to the broader public and not likely to have substantial impact outside the urban foraging subculture.

We imagine a social platform that maps edible produce grown within urban gardens, linking the location to garden facilitators' profiles and allowing the broader public to make requests, subscribe to produce from any local garden, or subscribe to notifications from specific nearby gardens. This mapping system could be extended to map all green spaces or potential install locations for urban gardens. Users interested in installing and maintaining a new urban garden could query all potential locations within a radius, and the system could allow them to contact building owners and request to install or manage an urban garden in their space. This way, application users could crowdsource the installation and care of potential plots even if they do not want to do it themselves.

While the proposed systems allow for social interfacing between urban agricultural producers and consumers, they also need recruitment processes to enlist a broader public previously unaware of urban farming or foraging. For this, we imagine a number of solutions including physical wall-mounted indicators at entrances of buildings hosting urban farms, or integration with existing digital map services. These indicators could display live data such as produce quantity, percentages along scales of ripeness, or even prices (if relevant to the owner) to allow passersby to decide when to check in on farms in person. By leveraging explicitly public physical and digital indicators, urban gardens can become more fully integrated into the public landscape as opposed to appearing private or concealed.

Conclusion

While urban gardens may not be able to outperform traditional rural farms in terms of efficiency or serve as a complete solution to food insecurity, they can serve as a valuable resource for building community, improving aesthetics and quality of life in cities, and increasing awareness of the food production system. We believe novel interactions that recruit broad participation and social connection across both urban growers and produce consumers are the missing link to catalyze city-wide urban garden success. Whatever interactions are developed should follow the three design guidelines outlined in the design guidelines section, supporting engagement equally across varying levels of interest. Such a system could have significant impacts on climate change and broadly impact public health by promoting a cultural shift to plant-based diets, and by educating urban residents on the intricacies of the food system.

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