Urban Agriculture and Water: Access, Management, and Policy

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1. Introduction

Urban agriculture has been increasingly explored as an avenue for improving mental and physical health, reducing crime, and promoting local food security (Branas et. al. 2011; Garvin et. al. 2013; Seigner et. al. 2018). Additionally, local food policy councils, nonprofit and governmental regional and municipal sustainability initiatives, and city comprehensive plans have sought to increase the integration of urban agriculture into future city planning (Hodgson et. al. 2011). However, urban agriculture faces multiple challenges including practical considerations (e.g., land tenure, water access, financial constraints) and system-wide improvements (e.g., stronger connections between policymakers, planners, and farmers, policy clarity and availability) (Rangarajan & Riordan, 2017).

Previous research has examined the use of Urban Agriculture Ordinances (UAOs) that permit and regulate urban agriculture within existing city zoning codes while mitigating land tenure conflicts (Spencer et. al. 2019; Meenar et. al. 2017). In a study of UAOs in cities across the US, we found that in spite of the fact that farmers and researchers indicate water access as a concern (Rangarajan & Riordan, 2017; Postel, 2015), formalized programs dedicated to addressing water cost and access were less common than zoning or other regulations. Thus, this research seeks to understand how farmers, non-profit organizations, and city governments are addressing the need for water access by urban agriculture projects. Our specific research questions were:

I. What interactions (both informal and formal) between gardeners, nonprofit organizations, and local governments facilitate water access for urban agriculture?
II. What improvements could be made to existing systems to better support water access for urban agriculture?

2. Literature Review

Creating programs that address water access and management create challenges in three areas: social (focusing on perceived challenges to urban agriculture as indicated by gardeners and nonprofit staff through interviews), technical (focusing largely on the problems associated with water/food safety, infrastructure, and stormwater management), and planning (focused on the growing usage of UAOs to regulate various aspects of growing in cities). A brief review of existing literature in each category is summarized below.

2.1 Perceived Social Challenges

Existing reviews of urban agriculture have often relied on case studies or interviews with urban farmers or gardeners, city planners, advocacy/nonprofit organization representatives, or municipal government officials to yield accounts of perceived challenges to urban agriculture. Such efforts include a report from Rangarajan and Riordan (2019) that explored the barriers to financial viability, urban agriculture as a social enterprise, and the rise of controlled environmental agriculture in cities through in-depth case studies. The report concluded with policy recommendations and considerations for urban farmers, federal policy, local-level policy

and planning, programs (e.g., farmer training, USDA programming), and research, extension, and education projects (Rangarajan & Riordan 2019). Similarly, Castillo et. al. (2013) categorized seven perceived barriers to urban agriculture based on interviews with farmers and urban planners in Chicago, including: lack of clear ordinances, overly specific zoning policies, land access, high costs, lack of farmer education or certification, finding insurance, and limited access to water. Concerns over water access specifically included "prohibitively expensive" water line installation, flooding concerns, and strict stormwater ordinances (Castillo et. al. 2013).

Beyond a policy perspective, additional work has analyzed the perception of urban agriculture as spaces of citizenship or as communally managed public spaces through interviews with gardeners and community members (Ghose & Pettygrove 2014; Napawan 2015). Hunter et. al. (2018) explored the uptake of best management practices for urban farms to enhance garden safety through focus groups of community gardens. These attitude- and behavior-based studies have thus contributed to qualifying the positive impacts on community or neighborhood development stemming from urban agriculture.

2.2 Technical Challenges

Urban agriculture is necessarily impacted by the abiotic constraints placed on cities that differ from their rural counterparts. Urban water infrastructure in particular faces increased stress as a result of microclimate variability, population demands, and ecosystem protection regulations over the past century (Hering et. al. 2013). Scholars have discussed two opportunities to ensure urban agriculture can continue to access water: first, to capitalize on technologies and techniques meant to optimize water use, such as soil moisture sensors; second, to diversify water sources through harvested rainwater or greywater (Wortman & Lovell 2013). Despite concerns over water contamination in relation to food production, studies of food crops irrigated with greywater reveal heavy metal and pathogenic microorganisms to be found at similar rates to those of plants irrigated with tap water and within WHO safety standards (Finley et. al. 2009). Additionally, existing EPA regulatory guidelines on water reuse highlight the large-scale use of recycled water following careful attention to WHO standards and prior research in Monterey County, CA on a large-scale produce farm (EPA, 2012).

Urban agriculture can also provide opportunities to improve existing city water management systems. According to Hering et. al. (2013), the integration of "managed natural systems" into urban water infrastructure will be essential to meet future water demands. Green infrastructure systems have been defined as those that "use vegetation, soil, and/or infiltration to retain stormwater and naturally filter out contamination" (McFarland et. al. 2019). Urban agriculture specifically can reduce hazardous runoff, with estimates of between 52.3 and 100 percent of precipitation retained by rooftop gardens (Wortman & Lovell 2013; Ackerman et. al. 2014). Additionally, Rogers & Hiner's (2016) spatial review of urban and peri-urban farms in east Austin, Texas found limited or no areas of high surface runoff, or hydrologically sensitive areas, on existing urban farms. Thus, the promotion of urban agriculture will be necessarily tied to both its potential positive impacts on city water infrastructure and its increased demand for scarce water.

2.3 Planning Challenges

Given the reliance of urban agriculture on existing zoning and city policies, Horst et. al. (2017) finds it necessary for planners to prioritize urban agriculture in long-term planning efforts to meet food justice goals. Planning strategies, including reducing barriers to urban agriculture

on privately held lands, reducing utility fees or property taxes for community gardens or farms, and allocating space or funds to urban agriculture, have been adopted across the United States with varying levels of success in improving food access and benefitting disadvantaged communities (Horst et. al. 2017). Existing areas of regulation for urban agriculture encompass land tenure (for example, through zoning, land banks, and conservation easements), animal husbandry (through both state- or municipal-level restrictions), built structures (for example, hoop houses or greenhouses), practitioner responsibility (requirements to test soil, control runoff, etc.), fiscal policy (sales, either onsite or at farmers' markets, tax abatements, or special use permit fees) (Meenar et. al. 2017). Additionally, planning for urban agriculture must include both making available land that is suitable for food production and developing infrastructure and support services city-wide, including market opportunities, transportation systems, waste disposal systems, and resource availability (Lovell 2010). Planning resources include case studies of cities that have integrated urban agriculture and recommendations for developing local comprehensive plans, municipal sustainability plans, zoning for urban agriculture, non-zoning regulations, and land-disposition policies (Raja et. al. 2008, Hodgson et. al. 2011).

A review of legal tools available to support urban agriculture include changes to municipal codes, tax incentives, public acquisition of land for urban agriculture purposes, and federal support opportunities, consisting of grants for research, consumer food subsidies, and educational programs (Pollans & Roberts 2014). An examination of land use and zoning policies across the United States similarly highlighted the main legal concerns of land acquisition and code-related issues, including zoning, keeping of animals, sales, buildings or structures, soil testing, and composting (Peters 2011). Additional legal research involves state Right to Farm Acts and nuisance laws' potential restrictions on urban agriculture (Smialek 2014, Heckler 2012). Recommendations based on a review of existing legal frameworks consist of the inclusion of urban agriculture into comprehensive plans and the development of a widely permitted urban agricultural use category to address common complaints with urban agriculture policy (Voigt 2011).

3. Methods

Initial interviews and email communication with urban agriculture experts identified a list of potential US cities that could serve as case studies for evaluating water access for urban farms and gardens. We used this list as well as cities identified through previous work focusing on urban agriculture ordinances to identify a preliminary list of cities. We next reviewed this list based on urban agriculture ordinance content, specifically what forms of urban agriculture are allowed and with what regulations; local nonprofit activities, specifically what resources, training, and financial support were available to farmers; and water access policies or programs. This initial review involved reading and categorizing each city's urban agriculture ordinance, city department-based online resources (i.e., city sustainability office or water department website), and community organizations/nonprofit activities before summarizing all cities' information into Appendix 1.

Both key informant (focusing specifically on nonprofit staff, city water department officials, and extension staff from each city) and snowball sampling were used to select interviewees from twelve cities, listed in Appendix 2. Given that interviewees came from a range of backgrounds, from managing specific community gardens to serving as a resource for both community organizations and for-profit farms (e.g., extension offices), the terms community

garden and urban agriculture will both be used to describe their experiences with gardeners and farmers. Sixteen open-ended interviews of thirty to forty-five minutes, following the questions outlined in Appendix 3, were conducted over Zoom and coded by the first author in NVivo. Following the first round of coding, the authors regularly discussed coding decisions. A second round of coding was completed in NVivo to account for jointly agreed-upon categorizations of cases.

4. Results

As predicted by previous research (Rangarajan & Riordan, 2017), although water access is key to successful urban agriculture, it is less commonly addressed directly through city programs than land tenure or zoning. Throughout this analysis, we will rely on a distinction between "formal" and "informal" management, which necessarily oversimplifies the different approaches to water access and management strategies. The distinctions between these two strategies will be discussed, followed by an explanation of the water-related policies and practices that are found to be unaffected by this distinction (institutional gardens, rainwater innovation, and water conservation education), as well as final recommendations from gardeners themselves. Finally, the degree of threat a lack of water poses to urban agriculture will be discussed.

4.1 Formal Management

We define formal management as those programs found in cities where water access is either entirely financed by the city or managed through an established, joint city-nonprofit program. The cities within each category are summarized in Table 1.

Table 1. Formal Management Types and Cities

City-financed water access
Utica, NY
Binghamton, NY
Joint city-nonprofit water access
Kansas City, MO
Buffalo, NY
Washington, DC

Although nonprofit and extension staff within the first category indicated they comparatively were able to access water easily, they highlighted additional complications in fostering and maintaining a supportive relationship with the city. In Utica, NY, water is provided through "water buffalos," or 240-gallon tanks filled regularly by the fire department for community gardens. Extension staff characterized this arrangement as a "favor" that lacked consistency:

> There were no leaders within this process to make sure that these gardens had water in them… You're asking a favor for the fire department, who are already busy doing their own piece right, and half of them are volunteers within a small area, so, you know, it was going back and forth.

They also described the process as heavily "reactionary," although this agreement with the fire department was now in its second year. Additionally, they stressed that it is not "their [the city's] responsibility to keep up" with refilling water buffalos. While gardeners were not required to pay for this water access, they relied heavily on extension staff developing positive and

communicative relationships with city agencies, such as the fire department, to access water throughout the growing season.

In Binghamton, NY, nonprofit staff emphasized that they felt "fortunate" for free water access and installation provided by the city. After a few years of an informal agreement, the process was formalized through a Community Green Space water permit that other community projects, such as parks, were able to apply for. Nonprofit staff compared their experience in Binghamton to the nearby Johnson City:

> Their legal counsel has said you can't give free water to these community gardens because it's a gift of public funds… The biggest cost was paying a private contractor to install the water. That cost $2,500; we normally have $10,000 to build a community garden. That was a huge upfront cost that makes it prohibitively costly to build community gardens in Johnson City.
> We're, maybe we're a little bit spoiled having the city of Binghamton give us free water, so we expect it from all the municipalities, because it's like hey we're also a very water rich community.

The above contrasted experiences indicate the significant financial benefit of having water access and infrastructure paid for by the city. Despite these challenges in nearby cities, they characterized the arrangement in Binghamton as working "very well." While providing free water was greatly appreciated in both cities, the formalized process in Binghamton appeared to reduce noted additional challenges with sustaining such a program.

Cities with a joint program varied in specific administration. Often, nonprofits were responsible for fielding applications to grants provided by the city. In Kansas City, MO, there existed a longstanding join program between two community garden-serving nonprofits and the city water department:

> Small local farms and community gardens can apply for the grant, and they apply through our organization. If it's a farm we refer them on to Cultivate Kansas City and one of their staff members will go out and do a site visit and really look at their whole water situation, so can they catch rainwater from someplace? Do they need to install a new water line that's hooked up to city water? And then we do the same thing for community gardens… Based on our knowledge of what works and what doesn't, they're invited to apply for the grant.

The program in Kansas City displays the highest level of formality of all water access programs surveyed, as it relies on a well-developed network between the city and two urban agriculture-serving nonprofits, one connected to community gardens, and one connected to for-profit farms. Nonprofit staff noted that the deciding committee, made up of representatives from the water department, Cultivate Kansas City, Kansas City Grows, and community garden leaders, preferred to support gardens that had "struggled" for a few years prior to offering resources for water resources. After the grant, totaling $75,000 a year, is disbursed, the two nonprofit organizations provide assistance with actually installing preferred methods of water access, which ranges from water catchment devices to water lines to drip irrigation systems. Nonprofit staff also highlighted the limited range of the program to just a small geographic area, a particularly salient issue for Kansas City, as three separate municipal governments oversee the same city.

Similarly, in Buffalo, NY, individuals were able to apply through Grassroots Gardens Western New York, with one nonprofit staff member characterizing this relationship as "taken care of" for gardeners:

> Part of my job every spring is to negotiate and apply for the permits with the city council and we fill out the information and ask for the lots and then the council can decide to approve or deny access to that… We will assist with getting hydrant permits, so that's another thing that I navigate every year with the city.

They also noted that Buffalo provides those gardens that have been approved for hydrant permits free water access. Additionally, they have partnered with the Buffalo Sewer Authority to provide low cost or giveaway rain barrels. However, they mentioned technical challenges associated with hydrant access:

> We're tried unsuccessfully for 25 years to get the city to be willing to have not just hydrant access but to put spigots with no meters on them in the community gardens, or at least the community gardens that are more than 10 years old.

In Washington, DC, water was originally provided entirely by the city, as explained by the city's Parks and Recreation Department staff:

> It's some combination between us and them [Department of General Services] that pay for their utilities, but we see it as you know we're expanding to provide programs and resources to the community, so we're happy to pay for that as opposed to if someone wants to have their own personal farm we're not going to pay for that.

However, as community gardens have developed in the area, city department staff stressed the need to "get creative" and rely on partners and grants to support new farms. Water access in DC was therefore characterized as "mixed." The dedicated funding for community gardens in the city budget still indicates a more formalized approach to water management.

Although initial research indicated the importance of zoning to the formal management of urban agriculture, no interviewees mentioned zoning in relation to water access. Instead, zoning was connected more generally to where agriculture was allowed and what specific uses were allowed. However, individuals from Utica, Buffalo, and Phoenix noted that local ordinances could be an effective tool for promoting water access and safety.

4.2 Informal Management

We define informal management as the lack of such programs in cities where water access in a) independently provided by or managed by nonprofits, b) independently provided or managed by extensions, or c) entirely the responsibility of gardeners. Although groups a and b display some level of formality in that the organization exercises some regulatory authority to develop such water management program, interviews revealed a lack of long-term planning associated with these programs. Compared to the typology developed for formal management water access, cities within this category are likely to have a blend of water providers, depending on an individual's access to land.

Baltimore, MD, displays this blending of water access strategies. Although the existing Adopt-A-Lot program was referenced by multiple nonprofit and extension staff as an opportunity for water access to be subsidized by the city, allowing participating individuals to access water at a flat fee of $120 annually, the program was not expanding. One extension staff member characterized the program as a "handshake agreement," noting that the city had not intended to

support long term gardens. Individuals on privately owned land have similarly attempted to receive such a discount, but have largely run into bureaucratic hurdles:

> There are a couple of private landowners who have farms who have tried to get a reduce water rate for their for-profit farms with the justification that if they're using the water for irrigation, then it's not going into the sewer system, so they shouldn't' at least have to pay the sewer fee… they couldn't get ahold of the person in the water department who gave them permission, and they had to get a special contractor to install the water meter because the city didn't have enough people… I think at this point they're just not going to do it.

While opportunities exist to better support water access, the complicated network of city departments required to access such a reduction in fees can therefore serve as another barrier to effectively developing a program to support gardeners. Others in the city have relied on refilling water tanks with a hose from an adjacent lot, indicating that gardeners themselves are often responsible with developing water access strategies.

All three cities in California surveyed indicated a similar mix of individual and nonprofit- or city-sponsored access to water, highly dependent on one's ability to join a specific garden. In San Diego, individuals involved in the Resource Conservation District's plots could access water for between $100 to $130 annually, or around half their gardening fee. In Sacramento, one urban agriculture-serving nonprofit was able to negotiate with the city:

> We're paying around 40 times more per gallon than someone on a rural county water district… We went into negotiation with the city for a whole year with all of the data about the cost of water and the city ended up providing us with a $10,000 subsidy that we can draw from to cover half the water bill every season.

The cost of city water, particularly when compared to the water available in rural areas for traditional farming, therefore present additional challenges for community gardens. Beyond the grant provided, the organization also relied on technical and behavioral changes to moderate water use and costs:

> We just require everyone to only use drip irrigation, but that's pretty standard in the area anyway, so, I would say they know they're going to have to pay for it, so they also don't want to use a ton of water if they can avoid it.

The responsibility for reducing water cost is therefore divided between gardeners themselves and the broader organizations to which they belong to, such as a community gardening agreement. In Los Angeles, nonprofit staff noted that although the water rate has increased 285% in the past six years, "it's uneven what they [gardeners] are willing to do about it." Networks between gardeners were mentioned as an opportunity to promote conservation:

> Watering more sparingly and carefully for sure, particularly because it's a group, you could have some social standard for how much you respect the water, like do you ever leave the hose running, not if Joe is watching, you know you get caught… They also have adopted rules which say you can only water on Tuesdays and Thursdays and Saturdays… From the gardener's perspective it's all about keeping their fee to participate in the garden low.

Such solutions to reducing water demand, however, are all marked by a reliance on networks between gardeners and informal information-sharing, which, while effective in smaller areas, may not be as feasible across an entire large city. All three cities faced additional difficulties related to state regulations:

> Until Prop. 218 was passed in California about 10 years ago we used to have a discounted water rate. Prop. 218 was passed by the voters of California, so no water system can treat one class of customers different from another. (Los Angeles, nonprofit)

Individuals not associated with established nonprofits in the area would therefore be required to pay the municipal rate, creating demand to join such programs, with the gardens in San Diego touting a "four-year waiting list."

In Atlanta, GA, extension staff noted that water access is mainly the responsibility of gardeners, potentially resulting in challenges for new or smaller farmers:

> The cost of installing irrigation—that might be a barrier for small farmers here because drip irrigation is really something that's very beneficial to small scale and market gardeners, and that's primarily what we have in this county as well… City water can be pretty expensive too… There are grants to assist with like irrigation installation and farm costs from numerous nonprofits around Atlanta so I'd say that's the biggest way farmers can offset their costs.

Gardeners were therefore more reliant on grants from an outside organization, such as a nonprofit supporting local food systems or nutrition education, to access necessary water infrastructure. In Houston, TX, a similar issue of water accessibility was highlighted:

> You know you're going to have a higher water bill if you're having a community garden, for sure. It's definitely not like all paid for somehow by somebody else, it is definitely an issue.

Although nonprofit staff indicated that an "agriculture exemption" existed that would allow for a lower water cost by eliminating sewer fees, they mentioned that it was uncommon and would require another meter.

In cities where informal management is used, siting of gardens more frequently is explicitly concerned with water access than in cities using a formal management strategy. In Phoenix, AZ, siting near the Salt River Project was preferable:

> Water is available through the city of Phoenix through municipal water, and then we have water available through the Salt River Project which is really flood irrigation water. Those areas that have access to flood irrigation, that water is less expensive… So, we're [Phoenix Office of Environmental Programs] working closely with the SRP to figure out where those areas are and where we might be able to put farms or larger community gardens.

A researcher associated with ASU described the problem in Phoenix as the city's "byzantine allocation system" causing water to be "artificially scarce." Specifically, the legal constraints imposed by the 1980 Groundwater Management Act were brought up by multiple Phoenix interviewees, including a prohibition on municipal water access for farms above 2 acres in the city. Tiger Mountain Foundation, a local nonprofit garden, was able to access water through the aforementioned Salt River Project for around $400 a year but noted their organization's long-term commitment to water efficiency methods, including water blankets. Even though they were

able to access preferential siting, nonprofit staff indicated water access in the area was fundamentally "unsustainable."

Extension staff in both Atlanta and Baltimore noted that they advised potential gardeners to consider water access during initial site evaluations:

> When someone comes to us, but they haven't found a location yet, we definitely do encourage them to think about where the water is going to come from, because that is definitely a limiting factor if you don't have that municipal water access. (Baltimore, extension)

In Sacramento, nonprofit staff indicated that although water access was not the "leading determinant" of garden site placement, "you have to be prepared to fundraise if it doesn't have water."

While informal management strategies differed widely, all were similar in their reliance on gardeners themselves to pay for water, either at the municipal or at a partially subsidized rate. Such dependence raised fundamental equity concerns, as highlighted by UGA extension staff:

> There's a lot of financial hurdles, especially even on the super small scale… the finances really limit the people and the kind of demographics of who can actually own a farm and who can viably make that work.

Therefore, while some gardeners may find informal management strategies suit their water access needs, there is a risk that such requirements that gardeners mostly fund their own water bills and related infrastructure bar some individuals or organizations from even starting a community garden.

4.3 Institutional Gardens

Institutional gardens are defined as "gardens or orchards located on private or public institutional property (school, hospital, faith-based organization, workplace) in a residential, commercial, or mixed-use area, gardened by an organization or business" (Hodgson et. al. 2011). Although they are typically managed with some level of formality, resulting in formal water access, the differences highlighted in interviews indicated that institutional gardens enjoyed certain advantages and faced certain challenges unique from those gardens associated with nonprofits or community members that had formal access to water. Multiple individuals noted clear benefits associated with institutional gardens in accessing resources:

> When it comes to like institutional community gardens and urban growing, yeah, I think there's always a benefit… there might be possible grants, as well as money available for those particular gardens and maybe staff and hourly time. (Utica, NY)

> An organization will just immediately have probably some more funding, support, there might be a staff member who's like designated to help out with the garden where they can be out there and dedicated to it. (Kansas City, MO)

Institutions therefore benefitted from existing labor resources (such as teachers, who often were cited as the main volunteers for school gardens) and opportunities for funding. Additional physical infrastructure benefits were noted by a nonprofit staff member who worked with plots across the city:

> One [of our plots] was owned by the school district, and it was a one-acre field that was being sprinkler irrigated, so in that instance we already had water… With the school district, they're not sitting there with a for sale sign on it waiting to make a profit off of that land, so I feel like our school district site is our most secure tenure. (Sacramento, CA)

That the garden was connected to a well-established institution allowed for less expensive initial water access and resolved potential concerns over land tenure, an issue described in multiple interviews as a limiting factor. However, other interviewees noted challenges faced uniquely by institutional gardens:

> We've had quite a few groups that are just so overwhelmed because it's like not fully written into their job description…we just had a garden that's at a big health clinic that was an awesome garden, looked wonderful, but the staff was totally overwhelmed, they weren't able to get good volunteers, and so they had to put it on pause. (Kansas City, MO)

> Their biggest problem is they don't have people to come in during the summer, because kids can say oh I'll do it, but their parents have to bring them in, or they have to find transportation, so most of the time it ends up being the teachers… and then the garden just falls over until they come back in August. (Atlanta, GA)

Expecting that a garden be supported by existing staff from the institution can therefore place additional burdens on individuals and result in gardens not being well maintained or needing to be closed. While institution-based gardens can be viewed as formal, with many organizations either directly providing through their own funding or applying for grants to provide water access for gardens on their land, they also display challenges in maintaining the garden annually and integrating the necessary labor into existing staff roles that distinguish these gardens from other formally managed cities surveyed.

4.4 Rainwater Innovation

Rainwater-related infrastructure was less commonly used than originally predicted. Most interviewees indicated basic obstacles to effective rainwater usage, including lack of a nearby structure to catch water off of, space limitations, food safety, and climate. In Buffalo, NY, nonprofit staff noted that although a third of gardeners used rainwater catchment, none of them were able to use their system to water the entire garden. Regardless of noted inefficiency, many interviewees noted that gardeners were personally interested in using rainwater, even if it could not water their entire garden:

> Some groups just love the idea of catching rainwater and they're like, 'Oh, and I get to save money, great!' (Kansas City, MO)

> Most of them are very passionate about things like conserving water and protecting the environment, so that's usually an important motive for them. (Baltimore, MD)

These environmental or educational motivations were most commonly cited as the reason individuals adopted rainwater catchment techniques. There existed, however, significant opportunities in most cities to have access to rain barrels or rainwater harvesting education. Extension staff in Atlanta, Baltimore, and Utica indicated that they participated in some form of

education or programming related to rainwater catchment. Additionally, nonprofits in San Diego and Buffalo were involved in demonstration rainwater catchment structures.

Interviewees also highlighted various projects that innovatively accessed water. In Phoenix, city government staff noted a recent grant program meant to improve water efficiency:

> We just recently awarded a small amount that we received from ASU to three farmers towards putting things like shade structures and solar energy on their farms to help them be more water efficient and address the heat as well.

In Washington, DC, city government staff explained one particularly creative project developed after water line installation estimates came back too high:

> I built this half acre farm with little hoop houses, and it was 500 feet up on a hill behind a Rec Center, a really cool spot, but it didn't have water… we tried a lot of things, so we built gutters on hoop houses and all kinds of rain catchment systems, and we still had to get solar pumps… so we actually found some funding to build a solar water well.

In Los Angeles, nonprofit staff stated that although most changes were "behavioral, not mechanical," they were able to incorporate some technical innovations into their watering:

> We do have a technological startup that came to us and asked if we could identify a couple gardeners where they could show their new technology, which is a soil moisture sensor, and they got that deployed and tested.

These three limited-scale innovations indicate the informality of such water efficiency and rainwater catchment mechanisms. These technical innovations have not been seen as standard practice in the cities survey. Given the challenges with implementing these technologies, they faced similar adoption challenges as rainwater catchment systems. Although many gardeners preferred to use such innovations for their perceived environmental benefits, most nonprofit, extension, and city government staff viewed them as a relatively not impactful option for accessing water.

4.5 Water Conservation Education

Many interviewees also highlighted the importance of water conservation education. For example, nonprofits and extensions described themselves as providers of information:

> One of the main things [our organization] does is education in terms of water use like, how do you water efficiently, you know as in, in the morning, in the night, or using drip irrigation, or it's suggested that people often use cover crops. (Houston, TX)

> Our job, primarily, is to work out of these offices and take information and research generated at the university level, synthesize it and break it down into programming, publications, and articles and deliver it to our community. (Atlanta, GA)

Many organizations interviewed therefore saw themselves as an educational, rather than financial, resource for gardeners. Additionally, nonprofit staff in Arizona emphasized the importance of water conservation education from an early age, noting that "water efficiency is a learned behavior." They also referred to a general need to be more "conscientious in terms of

environmental efficiencies." This improved water education could include knowledge of overwater, a problem highlighted on the West Coast in particular:

> Community gardens are overwatering by an enormous amount, which could pose a challenge by inflating actual water demand. (Phoenix, AZ)

> So many people overwater… they're used to doing it the way they did it. (Los Angeles, CA)

Education of gardeners, as an area frequently left to local extension staff, could therefore be targeted towards water efficiency and conservation to prevent excessive waste. Nonprofit staff in Los Angeles also noted that communication between gardeners in collaborative environments (for example, shared plots) was an effective way of dispersing information and encouraging experimentation in gardening and watering techniques.

4.6 Proposed Solutions

Each interviewee was asked to describe potential solutions to existing barriers in urban agriculture in response to an open-ended question. Individuals in cities with formal water access tended to suggest solutions that mirrored existing regulatory strategies. For example, in Utica, a city where the local fire department provides and pays for all water, extension staff noted that charging for water access, as long as it was not prohibitively expensive, could be a good thing and contribute to helping "growers understand their responsibilities." In Buffalo, nonprofit staff highlighted the importance of shifting city attitudes, drawing on their experience in nearby Johnson City:

> So, helping municipalities understand how, you know, providing free water to a community garden is not a gift of public funds.

In Washington, DC, city department staff suggested creating "two tracks" for water access: one for developers, and one for gardeners, with the latter at a less costly rate. In Kansas City, nonprofit staff mentioned it would be beneficial to expand the existing program across state lines and into surrounding counties, which were not eligible for existing grants. These suggestions highlight that individuals who currently dealt largely with prescribed laws and existing programs developed by or with the city imagined future changes to take a similar form, mainly as additional regulations.

Interviewees from cities that were less formally managed tended to view solutions to water access as tied to education. In Houston, it was suggested that nonprofit organizations improve their promotion of rain barrels. In Los Angeles, the importance of soil health to watering effectively was highlighted:

> It will be good if people were to spend more time thinking about their soil. If they did soil improvement, you know, added organic matter if they have sandy soil, they wouldn't have to water as much.

Individuals currently relying on informal water access systems tended to view solutions as similarly informal changes taken by individual gardeners to improve water availability or reduce demand.

Other solutions were more generally applicable to the regulation of urban agriculture. In Baltimore, extension staff noted the complexity of existing rules and decision-making:

> The more clear and simple you can make the system, the less frustrated the gardeners will be. Even if the answer is no, it's a lot better to know that the answer is no right up front than it is spend a year being bounced through phone trees.

Baltimore was categorized as a city that largely dealt with water through informal access mechanisms, indicating that those who relied on networking or community organizations to provide water desired a more formal approach.

The final category of recommendations focused on those unrelated to water access but impactful to the growth of urban agriculture and community gardening overall. As previously discussed, the issue of land access and land tenure were highlighted. One nonprofit staff member from Phoenix summarized the interdependent relationship between water access and land tenure, explaining that even if you had access to water, if your lease was up in a few months, water access becomes "moot." These suggestions align with preexisting research that emphasizes the importance of securing land to urban agriculture overall. Finally, two interviewees emphasized the increasing importance of marketing for growers, focusing more on their experience with commercial farmers than community gardeners. Both indicated that further support from the city or extension, such as a local food hub or business education, could improve a farmer's ability to make their farm viable financially. Although these suggestions are not directly tied to water access, they reveal additional areas that cities could improve upon to better support urban agriculture.

5. Discussion

Our work with nonprofit and city government staff supports existing research that while formalized programs supporting water access for farmers are relatively uncommon, there exists significant needs for codified or otherwise secure water access (Rangarajan & Riordan, 2017; Castillo et. al. 2013). While our research does not conclusively label one mechanism of access as preferable, it suggests that nonprofit staff felt formal agreements were more effective. However, this research suggests that while these cities with a developed and sustained program may have some advantages in securing long term water access for community gardens, the gardeners within these cities face additional challenges in maintaining a facilitative relationship with the city. Additionally, our study indicates the limits on rainwater catchment and technological innovation as a means for improving water access. Finally, our study makes an important distinction between land access or tenure and water access in terms of the use of zoning or ordinances.

Cities surveyed were shown to range between informal and formal agreements to provide water to gardeners. Existing research suggests that gardeners view water access as an unmet need (Castillo et. al. 2013). Our work provides examples of cities in which that need is fully, partially, or not at all met by cities, urban agriculture-serving nonprofits, and extensions, revealing the wide variety of opportunities to better support gardeners. Additionally, the experiences of those in cities with formal access programs, compared to those in cities with no formal system for water access, highlight the importance of institutionalized support for community gardens in accessing water. Some of the difficulties faced by gardeners in areas with informal water access included confusing or unclear regulations, high water costs, siting concerns, and reliance on

potentially ineffective agreements or innovations, such as watering on certain days or using rain barrels. These challenges were isolated to those cities with little to no formalized government or nonprofit support, indicating that future plans to address gardener needs should be more structured and formalized rather than decentralized and informal.

Although rainwater catchment has been highlighted as an exciting potential for gardeners to access water at a low cost and in an environmentally beneficial way (Lancaster 2016), our work found it was not able to supply most gardens with the water they required. Multiple interviewees stressed that rainwater catchment was not feasible in many of their gardens, which had no access to a structure to catch rainwater off of. Existing work also highlights the benefits of urban agriculture and rainwater systems to stormwater management (McFarland et. al. 2019); however, such benefits were not widely articulated in interviews. Our research therefore indicates there exists a gap between existing literature, which focuses largely on the technical benefits of rainwater usage, and gardeners' experiences, which mainly found rainwater catchment to be an ineffective but potentially educational or environmentally friendly option for watering.

Our work also indicated a distinction between the regulation of urban agriculture in relation to land use and water access. Existing research has highlighted the role of zoning and urban agriculture ordinances in promoting and regulating urban agriculture (Horst et. al. 2017; Meenar et. al. 2017; Hodgson et. al. 2011). Our findings indicate that no cities surveyed had programs that were formally codified into an ordinance and instead were developed through networks of gardeners, extensions, nonprofits, and city departments. Even the most formal access programs relied on a city budget allocation, rather than an UAO. Such differences in regulatory tools expands on previous research that has largely focused exclusively on ordinances as a means for improving access to urban agriculture.

5.1 Limitations

The results of this research are limited by the small sample size of interviews (n=16) and the overreliance on staff from urban agriculture-serving nonprofits or urban agriculture-related city government departments, rather than gardeners themselves. Additionally, there is an overrepresentation of smaller towns in New York state.

6. Conclusion

Our work expands upon previous surveys of ordinances and legislation regulating urban agriculture, focusing specifically on water access mechanisms for community gardeners. The results of this study indicate that water access can be supported through a wide range of effective mechanisms, each tied closely to local conditions and relationships between gardeners, nonprofits, extensions, and local governments. Our work also revealed that high expectations for rainwater catchment were not effectively met and that institutional gardens, although often accessing water through existing formal mechanisms, constituted a separate form of agriculture that faced its own unique challenges with institutional staff commitments. Finally, education was stressed throughout interviews, particularly in the area of water conservation, indicating a potentially larger future role for extensions in urban areas as providers of information.

This study has implications for individuals involved in regulating urban agriculture, including planners, policymakers, and local government staff, particularly those in environmental, water, or parks and recreation departments. The suggestions highlighted in section 4.6 offer opportunities for further improvement based directly on gardeners' experiences.

Finally, the distinction between informal and formal water access mechanisms, as well as the general preference for clarity and structure in city regulations and programs, can assist those designing water access programs in meeting articulated gardener needs.

Appendices

Appendix A1: City Profiles

City	City funded programs			Nonprofit funded programs	
	Monthly water bill reductions	Water provided by city	Grants for water infrastructure	Water provided by organization	Grants for water infrastructure
Atlanta, GA	X				
Baltimore, MD	X		X		
Binghamton, NY		X			
Buffalo, NY		X		X	
Houston, TX	X				
Kansas City, MO			X		X
Los Angeles, CA					
Phoenix, AZ					
Sacramento, CA	X			X	
San Diego, CA					
Utica, NY		X			
Washington, DC		X	X		

Appendix A2: Interviews

City	Role	Organization
Atlanta, GA	Extension	University of Georgia Extension
Baltimore, MD	Nonprofit	Baltimore Farm Alliance
Baltimore, MD	Extension	University of Maryland Extension
Binghamton, NY	Nonprofit	VINES Urban Garden
Buffalo, NY	Nonprofit	Grassroots Gardens WNY
Houston, TX	Nonprofit	Urban Harvest
Kansas City, MO	Nonprofit	Building a Sustainable Earth Community
Kansas City, KC	Nonprofit	Kansas City Community Gardens
Los Angeles, CA	Nonprofit	Los Angeles Community Garden Council
Phoenix, AZ	Educator	Arizona State University
Phoenix, AZ	Government	Phoenix Office of Environmental Programs
Phoenix, AZ	Nonprofit	Tiger Mountain Foundation
Sacramento, CA	Nonprofit	West Sac Urban Farm
San Diego, CA	Nonprofit	Resource Conservation District of San Diego County
Utica, NY	Extension	Cornell University Extension
Washington, D.C.	Government	DC Parks and Recreation

Appendix A3: Interview Protocol

Interview Questions	Purpose
What does your organization see as its role in relation to urban agriculture?	Background information
What kinds of issues or services do gardeners bring to your organization most frequently?	Degree of importance of water access
To what degree is water access an issue for the gardens you work with?	Degree of importance of water access
What factors most heavily impact water access?	Challenges
Can you tell me how you access water?	Program details
How would you describe your city's water-related urban agriculture program?	Program details
What barriers do you believe still exist to expanding urban agriculture?	Program details, challenges
Has your organization supported gardeners in using water catchment or other innovative techniques for water access? (Follow up: Have these techniques been effective in lowering costs or improving water access?)	Rainwater/technology usage
Site-specific questions, e.g., Your website mentions that you help gardeners access hydrant permits; can you explain what that process looks like? Or, what kinds of water infrastructure are supported by your grants?	Program details
Is there anything you want to add that we haven't discussed, or anything you'd like to add on to?	Program details

References

Branas, Charles C., Rose Cheney, John MacDonald, Vicky Tam, Tara Jackson, and Thomas Ten Have. 2011. "A Difference-in-Differences Analysis of Health, Safety, and Greening Vacant Urban Space." *American Journal of Epidemiology*, July. https://doi.org/doi: 10.1093/aje/kwr273.

Castillo, Sheila, Curtis Winkle, Stephen Krauss, Amalia Turkewitz, Cristina Silva, and Edie Heinemann. 2013. "Regulatory and Other Barriers to Urban and Peri-Urban Agriculture: A Case Study of Urban Planners and Urban Farmers from the Greater Chicago Metropolitan Area." *Journal of Agriculture, Food Systems, and Community Development* 3 (3): 155–66. http://dx.doi.org/10.5304/jafscd.2013.033.001.

Finley, Sara, Suzelle Barrington, and Darwin Lyew. 2009. "Reuse of Domestic Greywater for the Irrigation of Food Crops." *Water, Air, and Soil Pollution* 199: 235–45. https://doi.org/10.1007/s11270-008-9874-x.

Garvin, Eugenia, Carolyn Cannuscio, and Charles C. Branas. 2013. "Greening Vacant Lots to Reduce Violent Crime: A Randomised Controlled Trial." *Injury Prevention* 19: 198–203. https://doi.org/DOI: 10.1136/injuryprev-2012-040439.

Ghose, Rina, and Margaret Pettygrove. 2014. "Urban Community Gardens as Spaces of Citizenship." *Antipode* 46 (4): 1092–1112. http://dx.doi.org/10.1111/anti.12077.

Heckler, Susanne. 2012. "A Right to Farm in the City: Providing a Legal Framework for Legitimizing Urban Farming in American Cities." *Valparaiso University Law Review* 47 (1): 217–66.

Hering, Janet G., T. David Waite, Richard J. Luthy, Jörg E. Drewes, and David L. Sedlak. 2013. "A Changing Framework for Urban Water Systems." *Environmental Science & Technology* 47 (Special Issue: Design Options for More Sustainable Urban Water Environment): 10721–26. https://doi.org/dx.doi.org/10.1021/es4007096.

Hodgson, Kimberley, Marcia Caton Campbell, and Martin Bailkey. 2011. "Urban Agriculture: Growing Healthy, Sustainable Places." American Planning Association. https://planning-org-uploaded-media.s3.amazonaws.com/publication/book_paperback/PAS-Report-563.pdf.

Horst, Megan, Nathan McClintock, and Leslie Hoey. 2017. "The Intersection of Planning, Urban Agriculture, and Food Justice: A Review of the Literature." *Journal of the American Planning Association* 83 (3): 277–95. https://doi.org/10.1080/01944363.2017.1322914.

Hunter, Candis, Dana Williamson, Melanie Pearson, Eri Saikawa, Matthew Gribble, and Michelle Kegler. 2020. "Safe Community Gardening Practices: Focus Groups with Garden Leaders in Atlanta, Georgia." *Local Environment* 25 (1): 18–35. https://doi.org/10.1080/13549839.2019.1688268.

Karris, Kim, Sarah Benedict, Anna Baggett, Rachel Will, and Samyukth Shenbaga. 2019. "East Point City Agriculture Plan." Atlanta Regional Commission. https://static1.squarespace.com/static/543c2e74e4b0a10347055c4d/t/60009539493e8f6ee6afebfb/1610650939822/East+Point+City+Agriculture+Plan+%286%29.pdf.

Lancaster, Brad. 2016. "Planting Abundance: Alternative Water Sources for Urban Farms." In *Sowing Seeds in the City*, 373–88. Springer, Dordrecht. https://link-springer-com.proxy.library.cornell.edu/chapter/10.1007/978-94-017-7453-6_27.

Lovell, Sarah. 2010. "Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States." *Sustainability* 2 (8): 2499–2522. https://doi.org/10.3390/su2082499.

McFarland, Andrea, Larissa Larsen, Kumelachew Yeshitela, Agizew Nigussie Engida, and Nancy Love. 2019. "Guide for Using Green Infrastructure in Urban Environments for Stormwater Management." *Environmental Science: Water Research & Technology* 5 (February): 643–59. https://doi.org/10.1039/C8EW00498F.

Meenar, Mahbubur, Alfonso Morales, and Leonard Bonarek. 2017. "Regulatory Practices of Urban Agriculture: A Connection to Planning and Policy." *Journal of the American Planning Association* 83 (4): 389–403. http://dx.doi.org/10.1080/01944363.2017.1369359.

Napawan, N. Claire. 2015. "Production Places: Evaluating Communally- Managed Urban Farms as Public Space." *Landscape Journal* 34 (1): 37–56. https://doi.org/10.3368/lj.34.1.37.

Peters, Kathryn. 2011. "Current and Emerging Issues in the New Urban Agriculture: A Case Study." *Journal of Food Law & Policy* 2 (2): 297–356.

Pollans, Margot, and Michael Roberts. 2014. "Setting the Table for Urban Agriculture." *The Urban Lawyer* 46 (2): 199–225.

Postel, Sandra. 2015. "Securing Water for Urban Farms." *National Geographic Society Newsroom* (blog). 2015. https://blog.nationalgeographic.org/2015/01/08/securing-water-for-urban-farms/.

Raja, Samina, Branden Born, and Jessica Kozlowski Russell. 2008. "A Planners Guide to Community and Regional Food Planning: Transforming Food Environments, Facilitating Healthy Eating." 554. American Planning Association. http://www.planningclimatechange.org/public/file/Planners%20Guide%20to%20Community%20and%20Regional%20Food%20Planning.pdf.

Rangarajan, Anu, and Molly Riordan. 2019. "The Promise of Urban Agriculture: National Study of Commercial Farming in Urban Areas." United States Department of Agriculture Agricultural Marketing Service. https://smallfarms.cornell.edu/wp-content/uploads/2019/12/Promise-of-Urban-Ag_Full_102919-1.pdf.

Rogers, Charles, and Colleen Hiner. 2016. "Siting Urban Agriculture as a Green Infrastructure Strategy for Land Use Planning in Austin, TX." *Challenges in Sustainability* 4 (1): 39–53. https://doi.org/10.12924/cis2016.04010039.

Santo, Rachel, Anne Palmer, and Brent Kim. 2016. "Vacant Lots to Vibrant Plots: A Review of the Benefits and Limitations of Urban Agriculture." Johns Hopkins Center for a Livable Future. https://clf.jhsph.edu/sites/default/files/2019-01/vacant-lots-to-vibrant-plots.pdf.

Siegner, Alana, Jennifer Sowerwine, and Charisma Acey. 2018. "Does Urban Agriculture Improve Food Security? Examining the Nexus of Food Access and Distribution of Urban Produced Foods in the United States: A Systematic Review." *Sustainability* 10. https://doi.org/10.3390/su10092988.

Smialek, Chelsea. 2014. "Take a Walk Through the Cities' Gardens: Comparing Detroit's New Urban Agriculture Zoning Ordinance to Others of Its Kind." *University of Detroit Mercy Law Review* 91 (3): 345–270.

Spencer, Candace A, Catherine G Campbell, Anna Prizzia, and Liz Felter. 2019. "How to Establish an Urban Agriculture Ordinance: HS1327." *EDIS* 2 (April). https://doi.org/doi.org/10.32473/edis-hs1327-2019.

Thilbert, Joël. 2012. "Making Local Planning Work for Urban Agriculture in the North American Context: A View from the Ground." *Journal of Planning Education and Research* 32 (3): 349–57. https://doi.org/10.1177/0739456X11431692.

US Environmental Protection Agency. 2012. "Guidelines for Water Reuse." EPA/600/R-12/618. Cincinnati, OH: National Risk Management Research Laboratory. https://www.epa.gov/sites/production/files/2019-08/documents/2012-guidelines-water-reuse.pdf.

Voigt, Kate. 2011. "Pigs in the Backyard or the Barnyard: Removing Zoning Impediments to Urban Agriculture." *Boston College Environmental Affairs Law Review* 38: 537–66.

Wortman, Sam, and Sarah Taylor Lovell. 2013. “Environmental Challenges Threatening the Growth of Urban Agriculture in the United States.” *Journal of Environmental Quality* 42 (5): 1283–94. https://doi.org/10.2134/jeq2013.01.0031.