Evaluating Urban Agriculture as a Water Resource Management Tool: A Policy Roadmap for Colorado

Prepared for:
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Introduction

Recognizing the movement towards local food and food production, the Front Range of Colorado has become home to a vibrant urban agriculture and community gardening network. Throughout Colorado and the Intermountain West there have been limited studies or research on whether urban agriculture and community gardens can support increased water supply reliability and provide green stormwater infrastructure benefits.

The 2022 update to the Colorado Water Plan (CWP) marks the first major revision to the Water Plan since it was first published in 2015. With a rapidly growing population and the effects of climate change increasingly severe, the Plan update must address the challenges of the state's water supply with innovative solutions. As the current CWP stands it does not include water issues or opportunities regarding urban agriculture. To better understand the role urban agriculture and community gardens can play in addressing water resource challenges in Colorado, this research initiative addresses the following questions:

1. Can urban agriculture in Colorado help to both manage stormwater runoff and reduce demand on municipal water supplies? and if so,
2. What policy actions can be taken to encourage urban agriculture as a land use planning and water management tool?

This memo summarizes research on the water implications of urban agriculture and provides a suite of urban agriculture policy recommendations, developed by WaterNow Alliance and Western Resource Advocates, for inclusion in the next CWP update.

Project Overview

This project began with an in-depth literature review (**Appendix A – Literature Review Summaries)** on the water conservation and stormwater management potential associated with urban agriculture. This research also examined the social, ecological, and economic co-benefits of urban agriculture. WaterNow Alliance and Western Resource Advocates also conducted 16 stakeholder interviews with water providers, academics, and urban agriculture practitioners across the Front Range to gain a deeper understanding of the local context of water resource and stormwater management potential in relation to urban agriculture (**Appendix B – Stakeholder Interview List** and **Appendix C – Stakeholder Interview Questions**).

What is Urban Agriculture

In this memo, urban agriculture is defined as, "all production of plants and animals that takes place in or near a city, whether for personal use, for sale, or for charitable distribution, regardless of growing medium." This definition was developed in collaboration with the Colorado Water Conservation Board (CWCB) and graduate students from the University of Colorado Masters of the Environment Program.[1]

Urban agriculture provides numerous well-established social, ecological, and economic benefits, including improved community cohesion, neighborhood aesthetics, a local food source, reduced urban heat island effect, educational opportunities, reduced greenhouse gas emissions from transporting food, and more. [2]

Water Conservation

If designed and managed effectively, urban agriculture can conserve water in the landscape as compared to traditional high-water landscaping, such as turfgrass. However, there are a multitude of variables in the urban agriculture space that that can make these savings difficult to quantify including crop and soil type, irrigation methods, and garden management. In Colorado, few studies have been conducted to analyze water savings between traditional turfgrass and urban gardens, but all have shown that urban agriculture does have water savings potential.

In 2015, Denver Water teamed with Denver Urban Gardens to track water use at community gardens. The gardens used an average of 11 gallons of water per square foot annually, compared to traditional bluegrass lawns, which can use up to 18 gallons, a 40% water savings. The research conveyed that conversion of a 300 square foot section of lawn into a veggie garden could save 2,100 gallons of water annually. Denver Water and Denver Urban Gardens determined that water savings is another benefit that can be added to the positive list of co-benefits to growing local food.[3]

In the same year, Aurora Water converted two 600 square foot sites of turfgrass to vegetable gardens and recorded significant water savings. At City Hall, the amount of water used for irrigation dropped from 13,000 gallons over the course of a year to 2,500 gallons (81% water savings). At the Griswold Water Treatment Facility, the water use dropped from 10,250 gallons to 3,500 gallons (66% water savings). Overall, irrigation at both properties was reduced from 23,250 gallons to 6,000 gallons, meaning an average reduction of 74% over the course of the year of the study.[4]

Stormwater Management

As urban areas are continuing to increase the amounts of impervious surfaces (e.g., roads, parking lots, and buildings) to meet the needs of a growing population, green stormwater infrastructure (GSI) is being used to help mitigate stormwater runoff by allowing rainfall to better infiltrate into the ground and reducing runoff that would have otherwise flowed off-site and into the storm drain. Urban agriculture is an innovative GSI tool because it provides many more additional benefits than traditional stormwater management alone.[4]

In Colorado, GSI has mainly included ornamental plants, rather than edible crops. One exception, for example, is Sister Gardens farm managed by Frontline Farming in Denver. This garden was designed proactively to manage stormwater by using in-ground beds and contour farming (i.e., terracing) to direct and retain stormwater throughout the garden.[5] Other GSI design and management practices for urban agriculture include using soil amendments, native

grasses, and compost to slow the flow of runoff and capture water; planting in rain gardens or bioswales to increase the available water storage capacity; selecting both annual and perennial plants to always have living roots in the soil, as well as including cover crops in winter months, to enhance soil health and increase the infiltration properties of the soil.

Barriers and Policy Recommendations

Given the evidence in support of the water conservation and stormwater management potential of urban agriculture – and its many co-benefits - local and statewide policy actions should be taken to remove barriers and promote more widespread urban agriculture in Colorado. These key policy actions include potential research and knowledge gaps, water-related barriers and policy considerations, and land use barriers and policy considerations. The recommendations were developed based on common themes that emerged through informational interviews and a comprehensive literature review. WaterNow Alliance and Western Resource Advocates strongly encourage CWCB to include in the following policy actions in the CWP update.

Knowledge & Research Gaps

More information is needed to assess, quantify, and share the impact of more widespread urban agriculture on water conservation and retention. Critical knowledge gaps are summarized below:

1. Further studies and data are needed to support water use and water retention associated with urban agriculture in Colorado. Variables to consider include varying water years, irrigation type, crop type, garden layout, and scale of operation.
2. Research, training, and education on incorporating stormwater design and management practices into urban agriculture in Colorado.
3. Exploration of the water resource potential associated with next generation urban agriculture practices such as green roofs, indoor vertical farming, and Cannabis production.
4. Research and education on drought-resilient crops that will thrive in Colorado's changing climate.

Table 1. Water-Related Barriers & Policy Considerations

Barriers	Policy Considerations
Cost of water. Municipal water supplies are often cost prohibitive to urban farmers and may include unique infrastructure costs such as backflow prevention devices that require annual testing.	• The State, water providers, and/or other entities subsidize – or otherwise reduce - the price of water for urban farmers. • Provide subsidies to cover plot fees in low-income community gardens.
Access to water. Purchasing land and covering the cost of tap fees is cost-prohibitive to most urban farmers. Thus, many urban farms are established on	• City/water provider subsidizes tap fees to make land ownership more feasible.

properties that already have access to water such as churches, schools or City parks. However, on leased properties urban farmers typically don't have control over when water is turned on and off in the Spring and Fall.	• State and/or water providers provide funding for frost free hydrants or water tanks to prolong irrigation season.
Water Reuse. Most urban agriculture producers are not using any form of alternative, non-potable water supply due to limitations around using graywater, rainwater capture, and reclaimed water for urban agriculture.	• Update Regulation 86: Graywater Control Regulation to allow for irrigating edible produce. • Amend B1005: Residential Precipitation Collection to include Commercial, Industrial & Institutional Properties and allow for larger cisterns on urban farms. • State support for demonstration projects and education on using reclaimed water on edible crops (allowable per Regulation 84: Reclaimed Water Control).
Turf to Urban Agriculture Conversion. Approximately 18 Colorado water providers offer turf replacement incentive programs to their customers. However, many – if not most – do not allow for vegetable gardens an allowable form of waterwise landscaping.	• State to encourage/require water providers to consider urban agriculture as a conservation tool in Water Efficiency Plan updates. • Water providers update turf replacement rebate guidelines to allow for urban agriculture.
Water Education, Resources, and Funding. Address resource constraints in urban agriculture sector, particularly resources that reach under-served, low-income, and minority community members.	• State to support Frontline Farming and National Young Farmers Coalitions' Colorado Water Equity Partnership which engages under-represented farmers in water issues and discussion. • Develop education centers and demonstration projects such as CSU's SPUR campus. • Support urban agriculture representation on Basin Roundtables, especially the Metro and South Platte. • Create a Metro Area Water Conservation District to help direct funding and resources for farmers. • Water providers/urban farmers to collaborate with the Department of Agriculture's Urban Agriculture Specialist who can act as a hub for different resources and funding opportunities (pending hire).

Table 2. Land Use Barriers and Policy Considerations

Based on our findings, some of the biggest barriers to encouraging more widespread urban agriculture production were related to local land use access and limitations. Accessing land in urban spaces – which are becoming more and more dense and have many land use demands – can be very difficult, and urban farmers also face challenges related to the allowable use of that land.

Barriers	Policy Considerations
Access to land. Purchasing land is cost-prohibitive to urban farmers.	• Municipalities recognize and prioritize urban agriculture in a Comprehensive Plan and/or Sustainability Plan. • Municipalities update zoning code to allow for different forms of urban agriculture in all or most districts. • Municipalities require and/or incentivize urban agriculture in new development through community amenity requirements and/or as a required percentage of an open space or parks dedication. • Municipalities include guidelines for using urban agriculture for green stormwater management in a low impact development ordinance or an MS4 urban stormwater manual. • Municipalities review portfolio of parks and properties an develop long-term leases for community gardens.
Season extension. Most municipalities do not have processes in place for permitting high tunnels, which allow for season extension and pest control.	• Municipalities to develop streamlined, affordable permitting processes for high tunnels.
Edible Crop & Livestock Limitations. There are a wide variety of local code limitations affecting urban farmers including animal husbandry limitations, restrictions on planting in the right-of-way, setback requirements on small lots, and HOA guidelines restricting vegetable gardens.	• Municipalities to review and update codes to remove land use barriers to urban agriculture. • Amend HB 21-1229 to protect property owners from HOA restrictions on vegetable gardens.

While the actions listed above will primarily be implemented at the local level, the State can provide support by developing best practices, guidelines, and educational resources for incorporating urban agriculture into land use planning.

Conclusion

WaterNow Alliance and Western Resource Advocates hope that that the research findings summarized in this memo will result in the acknowledgement of urban agriculture - and its associated water benefits – in the forthcoming Colorado Water Plan update. The goal of the state and local policy recommendations is to act as a guideline for fostering more widespread urban agriculture in Colorado in the years to come.

References

[1] Cozzens, W., S. Grant, A. Nill, and A. Primo. 2020. Diversity, Equity, and Inclusion in the Colorado Water Plan Update Agricultural Sector. Masters of the Environment University of Colorado Boulder and Colorado Water Conservation Board.

[2] Santo, R., A. Palmer, and B. Kim. 2016. Vacant Lots to Vibrant Plots. A Review of the Benefits and Limitations of Urban Agriculture. Johns Hopkins Center for a Livable Future. 35 pp. Accessed online: https://clf.jhsph.edu/sites/default/files/2019-01/vacant-lots-to-vibrant-plots.pdf

[3] Kirk, J. 2015. Save Water Grow Vegetables Instead of Grass. Denver Water. Tap: News to Hydrate Your Mind. Accessed online: https://www.denverwater.org/tap/save-water-grow-vegetables-instead-of-grass

[4] Denwood, D. 2019. Vegetable Gardens. Grow Food, Save Water. Aurora Water, Water Conservation Department. Presentation on March 3, 2019.

[5] Emmad, F. (Frontline Farming) and W. Cozzens (Mile High Farmers). 2021. Personal communication with authors. August 16, 2021.

Appendix A – Literature Review Summaries

Title	Citation	Summary	Theme
Urban Farms: A Green Infrastructure Tool for the Chesapeake Bay	Boian, M., J. Hughes, and L. Deardorff. 2015. Urban Farms: A Green Infrastructure Tool for the Chesapeake Bay. American Rivers. https://www.americanrivers.org/wp-content/uploads/2016/05/AmericanRivers_UrbanAgricultureReport_final.pdf	Cities are constantly increasing the amount of impervious surfaces, such as roads, parking lots, and buildings, to meet the needs of a growing population. These surfaces do not allow rain to be absorbed into the ground resulting in high volumes of polluted water that pools or flows into storm drains. These drains empty into nearby streams and rivers and negatively impact their water quality. This is a significant problem for the Chesapeake Bay. Green infrastructure is being used as a tool to help solve these problems by restoring natural ground cover, allowing rainfall to infiltrate into the soil. This reduces runoff that would have previously flowed off of the site into storm drains. Urban agriculture is becoming an innovative green infrastructure tool because it provides many more additional benefits than traditional stormwater management alone. The report discusses the benefits provided to waterways and communities when urban agriculture is used as a stormwater mitigation practice. The following recommendations can help guide cities to increase their land use devoted to urban agricultural practices to benefit communities and clean water: 1. Provide training and education for urban farmers through accessible workshops on best stormwater management practices. 2. Identify viable vacant lots to be converted for the purpose of urban agriculture. 3. Eliminate the barriers to purchasing or obtaining a long term lease of a vacant lot. 4. Offer farmers access to funding opportunities for the incorporation of green infrastructure. 5. Allow a tax credit for farms that include green infrastructure into their farm design. 6. Include urban agriculture as a permitted use in city zoning code. 7. List stormwater management as a benefit or definition of urban agriculture in planning materials and zoning codes. 8. Require urban farms to develop a stormwater management plan if they increase the amount of impervious surfaces on the lot. 9. Require all soil tests and a nutrient management plan if using soil amendment. 10. Continue communication with the farms to ensure they are compliant with the city's urban agriculture ordinance.	Stormwater benefits; water quality; co benefits

Title	Citation	Summary	Theme
Urban Farms: Providing Food and Protecting Watersheds	Cox, J. 2015. Urban Farms: Providing Food and Protecting Watersheds. American Rivers. https://www.americanrivers.org/2015/06/urban-farms-providing-food-and-protecting-watersheds/	The article explores opportunities for ways to reduce stormwater runoff as well as provide access to healthy food in low-income areas. The practice of urban agriculture is a growing trend in inner-city neighborhoods across the county to address the issues of food deserts and stormwater runoff. Using urban agriculture as a green stormwater infrastructure practice can reduce the amount of nutrients that flow into waterways and destroy their ecological health and the community benefits they provide. Polluted runoff is a major source of water pollution in watersheds across the US. Increased development and urbanization combined with expensive water infrastructure updates have communities across the nation starting to incorporate innovative approaches to manage stormwater runoff, such as urban agriculture, which in turn will protect clean water and public health. Urban agriculture is a green infrastructure tool because it creates a pervious surface where an impervious surface once was, and plants have a propensity to soak up rainwater. Creating urban farms in vacant and unused lots surrounding neighborhoods can reduce the amount of stormwater runoff due to the addition of soils and plants. Urban agriculture can also improve the local economy by creating jobs and increasing property values, improve nutritional health of underserved communities by giving local access to healthy food options, and connect residents to their environment by providing greenspace to enjoy.	Stormwater benefits; water quality; co benefits
Seeing Green: Urban Agriculture as Green Infrastructure	Urban Omnibus. 2012. Seeing Green: Urban Agriculture as Green Infrastructure. Architectural League of New York. https://urbanomnibus.net/2012/02/seeing-green-urban-agriculture-as-green-infrastructure/	In an effort to support and scale up farming in the city, researchers Tyler Caruso and Erik Facteau explore ways to prove the scientific and environmental benefits of rooftop and other urban farms, in particular, their ability to manage stormwater, with their research project, Seeing Green. Seeing Green is a research project that studies specific urban agricultural sites in the NYC area in order to demonstrate how urban agriculture should be considered a viable and important component of the city's green infrastructure. The researchers measure evaporation and evapotranspiration rates to create metrics to calculate how much water urban farms are managing, through both detention (temporary storage of excess stormwater) and retention (indefinite storage of excess stormwater) to know how much water urban farms keep from entering the sewer system, therefore reducing combined sewer overflows. These metrics are not defined in the article.	Stormwater benefits

Title	Citation	Summary	Theme
Urban Agriculture as a Green Stormwater Management Strategy	The Freshwater Society. 2013. Urban Agriculture as a Green Stormwater Management Strategy. University of Minnesota. https://www.arboretum.umn.edu/UserFiles/File/2012%20Clean%20Water%20Summit/Freshwater%20Urban%20Ag%20White%20Paper%20Final.pdf	The report describes the need that drives interest in green infrastructure, investigates major issues related to using urban agriculture as a green infrastructure strategy, identifies gaps in current research, summarizes actions other cities have taken on urban agriculture and green infrastructure, and frames a series of recommendations for next steps. Rainfall amounts are increasing in both amount and frequency. Stormwater infrastructure has a fixed and finite volume capacity, and may be insufficient to meet future demands. Green infrastructure offers a promising new approach to managing stormwater by reducing the volume of water that would otherwise flow to traditional stormwater systems. While there are a number of widely-used green infrastructure strategies and structures available to cities, urban agriculture and community gardens are not typically among them. In planning for healthy cities of the future, land use planners are looking beyond the single benefit of urban agriculture's potential as a stormwater management strategy, and evaluating the full range of benefits that derive from urban agriculture as a land use activity. Urban farms and gardens can improve the visual quality of neighborhoods, provide opportunities to socialize and cooperate with friends and family, connect urban residents to food systems, improve access to fresh, nutritious food, help in combating childhood obesity, diabetes, and poor nutrition, provide access to rare foods that support the cultural heritage of citizens, create opportunities for interracial and intercultural interactions, decrease crime, offer opportunities for recreation and relaxation when gardening outdoors, improve the food security of households, and help gardeners and urban farmers gain new knowledge and technical skills. The report explores topics around soil moisture, run-off levels, erosion and sediment loss, practices that can be transferred from the agricultural sector, information gaps and research needed, water holding potential of urban farm sites, guidelines for using stormwater on crops, urban soil contaminants, stormwater for growing food crops, soil testing requirements before growing and selling food crops, opportunities and barriers for using stormwater BMPs as community garden and urban agricultures sites to help meet NPDES requirements, and community gardening and urban agriculture as a community engagement strategy under the NPDES permit program.	Stormwater benefits; co-benefits (social connections, healthy food, public health, culture, safety, education)

Title	Citation	Summary	Theme
Seeding the City: Land Use Policies to Promote Urban Agriculture	Wooten, H. and A. Ackerman. 2011. Seeding the City: Land Use Policies to Promote Urban Agriculture. National Policy & Legal Analysis Network (NPLAN). Oakland, CA. https://www.changelabsolutions.org/sites/default/files/Urban_Ag_SeedingTheCity_FINAL_(CLS_20120530)_20111021_0.pdf	The report explores a framework for developing urban agriculture land use policy by considering land use laws, zoning codes and districts, and other laws affecting urban agriculture. Additionally, the report includes model comprehensive plan language for urban agriculture and a model zoning ordinance for urban agriculture that can serve as an example for communities to tailor and adopt amendments to their existing land use plans and zoning laws. The report defines urban agriculture and discusses its many co-benefits including promoting health, environmental sustainability, and economic vitality.	Co-benefits; policy, laws, and zoning
Urban Agriculture Impacts: Social, Health, and Economic: An Annotated Bibliography	Golden, S. 2013. Urban Agriculture Impacts: Social, Health, and Economic: An Annotated Bibliography. University of California Agriculture and Natural Resources. https://ucdavis.github.io/asi-database/uaannotatedbiblio-2013.pdf	This report focuses on articles that discuss economic, social, and health impacts of urban agriculture. The author defines urban agriculture as: "Urban agriculture includes production, beyond that which is strictly for home consumption or educational purposes, distribution and marketing of food and other products within the cores of metropolitan areas and at their edges. Examples include community, school, backyard, and rooftop gardens with a purpose extending beyond home consumption and education, innovative food-production methods that maximize production in a small area, farms supplying urban farmers markets, community supported agriculture, and family farms located in metropolitan greenbelts." The report contains 78 applicable resources/report summaries.	Co-benefits; definition or urban agriculture

Title	Citation	Summary	Theme
Vacant Lots to Vibrant Plots: A Review of the Benefits and Limitations of Urban Agriculture	Santo, R., A. Palmer, and B. 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	Urban agriculture has become a popular topic for metropolitan areas to engage in on a program and policy level. It is touted as a means of promoting public health and economic development, building social capital, and repurposing unused land. Food policy councils and other groups that seek to position urban agriculture to policy makers often struggle with how to frame the benefits of and potential problems with urban agriculture. In some cases, the enthusiasm is ahead of the evidence. This review provides an overview of the documented sociocultural, health, environmental, and economic development outcomes of urban agriculture. Demonstrated and potential benefits, as well as risks and limitations, of this growing field will be discussed. The report also includes recommendations for further research to strengthen the scholarship on urban agriculture.	Stormwater benefits; co-benefits (cultural, public health, economic)
Stormwater Runoff Benefits of Urban Agriculture	Hankard, M., M. Reid, R. Schaefer, and K. Vang. 2016. Stormwater Runoff Benefits of Urban Agriculture. University of St. Thomas. https://www.stthomas.edu/media/officeofsustainability/scpsp16projectreports/UrbanAgStormwaterReport.pdf	The study set out to determine if converting vacant lots to urban gardens would decrease stormwater runoff. Soils in urban gardens are likely to be more permeable and therefore absorb more stormwater compared to vacant lots, although data to support this hypothesis are lacking. To answer this question, the researchers used runoff coefficients found in literature review and from data previously collected at the University of St. Thomas to quantify the absorbance capacity of urban garden soils. They found that converting vacant lots to urban gardens could reduce stormwater runoff by around 85%. However, nutrient concentrations in any runoff that does come from urban gardens are likely to be 2-3 times higher in dissolved nitrogen, and up to 100 times higher in dissolved phosphorus concentrations, compared to typical urban stormwater, potentially undermining any stormwater benefits. Therefore, it is important to implement best management practices that minimize the possibility of runoff from urban gardens in order for these to function as green infrastructure.	Stormwater (benefits and concerns)

Title	Citation	Summary	Theme
Estimating stormwater runoff for community gardens in New York City	Gittleman, M., C. J. Q. Farmer, P. Kremer, and T. McPhearson. 2016. Estimating stormwater runoff for community gardens in New York City. Urban Ecosyst. DOI 10.1007/s11252-016-0575-8	Community gardens are critical ecological infrastructure in cities providing an important link between people and urban nature. The documented benefits of community gardens include food production, recreational opportunities, and a wide number of social benefits such as improving community stability, reducing crime, and physical and mental health benefits. While much of the literature cites community gardens as providing environmental benefits for cities, there is little empirical evidence of these benefits. Here the researchers examine the stormwater runoff benefits of community gardens by comparing two methods to estimate absorption rates of stormwater runoff in urban community gardens of New York City. The first method uses general land cover classes as determined by a land cover dataset; the second methods adds a land cover specific to community gardens — raised beds, typically used for food production. The researchers find that in addition to the stormwater mitigation performed by pervious surfaces within a garden site, community gardens in New York City may be retaining an additional 12 million gallons (~45 million liters) of stormwater annually due to the widespread use of raised beds with compost as a soil amendment.	Stormwater benefits
Sustainable Water Management for Urban Agriculture: Planting Justice, Oakland	Nolasco, J. 2013. Sustainable Water Management for Urban Agriculture: Planting Justice, Oakland. Pacific Institute. https://pacinst.org/wp-content/uploads/2018/07/sustainable_water_management_for_urban_agriculture3.pdf	The case study explores various water-efficient practices associated with urban agriculture, and highlights Planning Justice, an organization that incorporates principles of small-scale, sustainable food production with food justice and economic justice efforts. Urban agriculture faces unique challenges, including typically higher costs for land and water (as most urban farms utilize municipal water supplies) and smaller growing areas that are frequently in close proximity to homes and businesses. Thus, much of the urban agriculture movement is focused on practices that conserve resources and minimize inputs, particularly those that could be toxic such as synthetic herbicides and pesticides. There are a variety of water efficient practices that have been incorporated into the urban agriculture movement, including water harvesting, water reuse, and improved irrigation, which are futher described in the report.	Water conservation BMPs

Title	Citation	Summary	Theme
Urban Farming and Water Conservation: A Way of Life on the City Farm	Yagi, R. 2017. Urban Farming and Water Conservation: A Way of Life on the City Farm. Agriculture and Natural Resources, University of California. https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=24748	The article explores how urban farmers can conserve water through various best management practices such as fostering healthy soils, choosing the correct crops, proper irrigation systems and techniques, and more.	Water conservation BMPs
Save water. Grow vegetables instead of grass.	Kirk. J. 2015. Save water. Grow vegetables instead of grass. Denver Water TAP News. https://www.denverwater.org/tap/save-water-grow-vegetables-instead-of-grass	Denver Water partnered with Denver Urban Gardens to track water use at community gardens. The gardens use an average of 11 gallons of water per square foot annually, compared with traditional bluegrass lawns, which can use up to 18 gallons per square foot annually - a 40% water savings. The calculations showed that if you convert a 300-square-foot section of a lawn to a veggie garden, you could save 2,100 gallons of water annually.	Water conservation
Water Conservation in Community Gardens	Romer. J. 2012. Water Conservation in Community Gardens. Denver Urban Gardens (DUG). https://dug.org/water-conservation-in-community-gardens/	In 2012, Denver Water declared a Stage 1 drought (a voluntary reduction in outdoor water use) and with that news, Denver Urban Gardens developed this resource to encourage community gardeners to conserve water and educate them on how to be more water efficient. The article explores best management practices including water plants only when needed (i.e., when soil is dry, applying water to the soil not the plant, timing during the day, etc.), improving soil health (i.e., adding compost, which can result in a 20% decrease in water usage), watering by hand (instead of automatic irrigation), and other techniques to reduce water loss.	Water conservation BMPs

Title	Citation	Summary	Theme
Efficient Water Conservation Techniques	Denver Urban Gardens. 2015. Effective Water Conservation Techniques. Resource Sheet. Denver Urban Gardens School Garden and Nutrition Curriculum. https://dug.org/wp-content/uploads/2015/04/Water_Conservation.pdf	Gardening in Colorado mandates the conscious use of effective water conservation techniques. DUG believes community gardens should be models of efficient water use, especially in seasons of drought. Additionally, use of water conservation techniques has several other benefits including reduced water costs and weed proliferation. If the following techniques are applied, plants will respond by growing quickly and by producing an abundant harvest. DUG has also outlined a set of water restrictions required of all community gardeners in response to the on-going drought. Regardless of the duration of the drought, however, DUG advocates gardeners adopt and incorporate these techniques as a way of life. 1. Water plants in the cool of the day, especially during the evening. 2. Water the roots and soil, not the leaves. 3. Cultivate the soil before watering. 4. Compost throughout the season. 5. Space plants so that their mature leaves shade the soil surface. 6. Mulch any uncovered soil areas. 7. Check the soil for needed moisture. 8. Wilting leaves do not always call for water. 9. Utilize efficient watering tools. 10. Harvest frequently.	Water conservation BMPs
Edible Gardens versus Lawns	California Farm & Garden. 2021. Edible Gardens versus Lawns. https://cafarmandgarden.com/water-conservation-fruit-and-vegetable-gardens-vs-lawns/	California Farm & Garden in San Diego conducted a study estimating water usage between traditional laws and fruit/veggie gardens. The research showed that a fruit and vegetable garden in the same space as a lawn will reduce water usage by about 75%.	Water conservation

Title	Citation	Summary	Theme
Leave Your Lawn for Life on the Urban Farm	Cernansky, R. 2015. Leave Your Lawn for Life on the Urban Farm. TakePart. http://www.takepart.com/article/2015/07/27/replacing-lawns-urban-farms-saves-huge-amounts-water	The article explores case studies of water savings between traditional lawns and vegetable gardens. Vegetable gardens often use less water than many picturesque green lawns—in some cases, half as much, according to gardening and water experts. In Denver, for instance, residents, schools, and water agencies have started installing vegetable gardens to save water. The push to factor water consumption into the decision to replace lawns with urban gardens seems to be strongest in metropolitan Denver, but the potential exists in just about any drought-prone area. Denver Water, Colorado's largest water utility, used to promote xeriscaping—replacing lawns with drought-resistant plants—as the optimal water-saving way to landscape a piece of property. Today, though, the agency encourages people to look not just at the amount of water used but at the overall value that that water will provide. In 2010, the group calculated that community gardens used, on average, just over nine gallons of water per square foot each growing season—half of the 18 gallons that Kentucky bluegrass needs. That, however, is still more water than consumed by drought-resistant plants, which use between zero and four gallons per square foot. Aurora Water, the water agency that serves the city of Aurora, just east of Denver, is also pushing urban farms. After converting large grass plots that the agency owned to vegetable gardens at two sites, the city noted a 74 percent drop in irrigation. The agency also offers a gardening class for residents interested in learning how to grow vegetables. Urban Plantations, a San Diego company that designs and installs mini-farms, calculated that replacing a lawn with a fruit and vegetable garden will reduce water use by 66 percent.	Water conservation

Appendix B – Stakeholder Interview List

Name	Title	Organization	Location	Website
Dan Goldhamer	Director	Denver County Extensions – Colorado State University	Denver, CO	https://denver.extension.colostate.edu/
Diana Denwood	Sr. Water Conservation Specialist	Aurora Water	Aurora, CO	https://www.auroragov.org/residents/water
Erin West	Western Campaigns Director	National Young Farmers Coalition	Hudson, NY	https://www.youngfarmers.org/
Fatuma Emmad	Co-Founder	Frontline Farming	Denver, CO	https://www.frontlinefarming.org/
Frank Kinder	Water Efficiency and Sustainability Manager	Northern Water	Berthoud, CO	https://www.northernwater.org/
Helen Silver	Commissioner	Denver Sustainable Food Policy Council	Denver, CO	http://www.denversfpc.com/
Jeff Tejral	Manager of Water Efficiency	Denver Water	Denver, CO	https://www.denverwater.org/
Jessica Thrasher	Education and Outreach Manager	Colorado State University Stormwater Center	Fort Collins, CO	http://stormwatercenter.colostate.edu/
Lara Fahenstock	Sr. Director of Operations	Denver Urban Gardens	Denver, CO	https://dug.org/
Larry Stebbins	Founder	The Garden Father	Colorado Springs, CO	https://thegardenfather.com/
Liesel Hans	Water Conservation Manager	Fort Collins Utilities	Fort Collins, CO	https://www.fcgov.com/utilities/
Linda Appel Lipsius	Executive Director	Denver Urban Gardens	Denver, CO	https://dug.org/
Mara Rose	Co-Founder and CEO	Boundless Landscapes	Boulder, CO	https://www.boundlesslandscapes.com/
Monique Marez	Project Coordinator	Pueblo Food Project	Pueblo, CO	https://pueblofoodproject.org/
Quint Redmond	Co-Owner and CEO	Agriburbia	Keenesburg, CO	https://agriburbia.com/
Willow Cozzens	Equity and Food Policy Analyst	Mile High Farmers	Denver, CO	https://www.milehighfarmers.com/

Appendix C – Stakeholder Interview Questions

1. How do you interact with urban agriculture? *(If you are an active producer, please include location and size of your operation, and where you access your water resources, if known.)*

2. On a scale of 1 to 7, indicate how well the following definition captures your notion of urban agriculture: "all production of plants or animals that takes place in or near a city, whether for personal use, for sale, or for charitable distribution, regardless of growing method or medium." *(1 = very well, 7 = not well)*

3. What would you change about or add to the above definition of urban agriculture*? (Feel free to suggest modifications or propose an entirely different definition.)*

4. Do you think that urban ag can be a viable landscape water conservation option compared to existing landscapes (e.g., irrigated turf grass)? Why or why not?
    a. If yes, can you point to any examples of urban ag being used as a landscape water conservation tool in CO or beyond?
    b. What are some of the best management practices associated with water wise irrigation/landscaping practices for urban agriculture?
    c. Any challenges to using urban ag as a water conservation tool?
    d. Are you aware of any reports/resources that quantify water savings associated with urban ag in Colorado or beyond?
    e. *For producers:* Do you know your average monthly/yearly cost of water (including irrigation equipment)? Is water cost prohibitive?

5. Do you think that urban agriculture is a viable green stormwater management tool in Colorado? Why or why not?
    a. If yes, can you point to any examples of urban ag being used as a stormwater management feature in CO or beyond?
    b. More specifically, can you point to any examples of community gardens being designed in a way to better use /direct rainwater and reduce the need for potable supplies?
    c. Are there design or best management practices that practitioners should be aware of with regard to using urban ag as a GSI tool? (e.g. cut-outs in garden beds, soil amendment, swales/rain gardens, etc.)
    d. Any challenges to trying to use green stormwater strategies/features in urban ag or community gardens?

6. Are you aware of any reports/resources that quantify water savings associated with urban ag in CO and beyond *or* support urban ag as a viable stormwater management tool?

7. Do you feel there are any gaps in our knowledge around water resource management and urban ag? (e.g opportunities for case studies, follow-up research)

8. Would you like to see more widespread adoption of urban ag in Colorado?

9. Are there any water resource related challenges or barriers affecting urban ag?
    a. Is water cost prohibitive?
    b. Is obtaining access to water challenging? (e.g. tap fees, partnerships with institutions)
    c. Legal limitations around using alternative water sources?
    d. Anything else that comes to mind?

10. More broadly, are there any other barriers (policy, funding, capacity, knowledge, access to land, zoning issues) that exist to implementing more widespread urban agriculture in the Front Range?

11. Are there any local, regional, or state-level policies/programs that come to mind that could support greater adoption of urban ag in Colorado?

12. Do you think policy recommendations to support expansion of urban ag should be included in the State's forthcoming water plan update?

13. If follow-up analysis is determined useful for addressing this research question, would your city/utility/organization be interested in participating in a case study?