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Title: Fields of Opportunity: Exploring the Intersection of Urban Farming and AI Solutions for Food Insecurities in Black Communities
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Introduction

In the United States, one in five Black individuals experience hunger with food insecurity primarily because of poverty, limited food availability, and systemic inequalities (Dennard et al., 2022). Hunger and poor nutrition pose immediate health risks and hinder cognitive development and economic mobility, all of which minimize the individual's ability to thrive (Drewnowski, 2022). Examining the challenges Black communities encounter reveals that relying solely on traditional agriculture and food distribution methods is not enough to address the complexities of food insecurity and hunger. Urban farming, which encompasses the cultivation, processing, and distribution of agricultural products in urban and suburban areas. Various urban farming initiatives have positively impacted Black and low-income communities by enhancing access to nutritious food and providing valuable nutrition education. In addition, research has explored the potential of artificial technology (AI) technology to revolutionize the agricultural industry to combat food insecurity. Despite recognizing the individual promise of urban farming and AI technology, a significant knowledge gap exists regarding the combined impact of these innovations on Black farmers and communities. People of color own only 3% of all U.S. agricultural land, with Black farmers representing just 1% of the 3.4 million farmers in the country (Meredith, 2022; Worthy, 2022). In addition, challenges such as historical land dispossession, discriminatory lending practices, limited resource access, and racial inequalities persistently serve as barriers for Black farmers (Ackoff et al., 2022). These structural impediments not only hinder the adoption of technological advancements like AI but also contribute to the declining number of Black farmers who support Black communities nationwide.

Community members and organizations have widely acknowledged and benefited from the substantial advantages of urban farming initiatives. However, research on the impact of urban farming in Black communities is lacking, leaving a gap in statistical evidence that substantiates these experiences. Similarly, research exploring the integration of AI technology in agriculture has primarily focused on broader applications, with insufficient attention to its implications for Black farmers. This knowledge gap underscores the need for further research to understand the impact of urban farming and AI technology on Black communities and to address the systemic challenges they face in adopting such initiatives.

This capstone, serving as a comprehensive literature review, uses previous literature to navigate the landscape of food insecurity in Black communities and explore the potential benefits of urban farming and AI-driven solutions for these communities. We need to critically examine the challenges and consequences associated with pushing forward initiatives that involve AI in agriculture in Black communities. By understanding the nuanced interplay between technological innovation and systemic challenges, this capstone aims to pave the way for more informed and equitable approaches to addressing food insecurity within Black communities.

Food Security and Urban Farming

Food Security in Black Communities

At the 1996 World Food Summit, the United Nations Committee on World Food Security defined *food security* as "when all people constantly have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (The World Bank, 2024). Prior research (Cummins et al., 2005; Siegner, 2018) on fresh food access in low-income areas concentrated on food deserts (geographic areas where residents' access to affordable, nutritious food options is restricted or nonexistent) and the lack of grocery stores. However, scholars and policymakers have recognized that simply placing a grocery store in a former food desert has minimal impact on residents' fruit and vegetable intake. Low-income households often maintain their purchasing patterns even after the opening of a new supermarket, opting for familiar, affordable options over healthier alternatives (Devitt, 2019). This tendency is influenced by factors such as financial constraints, limited awareness of healthier options, and a preference for familiar foods.

Focusing on food deserts overlooks the deeper factors that create food insecurity (Colson-Fearon &Versey, 2022). Increasingly, society acknowledges historical and structural challenges like poverty, racism, and divestment in specific communities as fundamental causes of unequal access to affordable, nutritious food for the Black community (McClintock, 2008; McClintock et al., 2018). As a result, food sovereignty leader Karen Washington coined the term *food apartheid,* which describes a comprehensive framework that systematically undermines Black self-determination in controlling food, perpetuating unhealthy food saturation, predatory marketing, and supporting a discriminatory corporate-controlled food system (Colson-Fearon & Versey, 2022).

In the mid 20th century, common practices like redlining, along with white flight, actively promoted racial segregation (Crowe et al., 2018). Though redlining is not legally practiced today, other discriminatory practices, like mortgage lending discrimination, still perpetrate housing discrimination (Crowe et al., 2018). These practices have led to continuous racial and ethnic segregation, particularly evident in high-poverty neighborhoods where over a third of residents are Black (Jargowsky, 2014; Crowe et al., 2018). The growth of suburbs is intertwined with the historical placement of grocery stores, as grocery companies were attracted to suburban areas by white middle-class families with substantial buying power (Donohue, 1997; Pothukuchi, 2005). In contrast, urban neighborhoods lacked space for large stores and faced stringent regulations, depopulation, and safety concerns (Pothukuchi, 2005; Crowe et al., 2018). These factors along with the perception of urban crime, kept large grocery stores out of urban neighborhoods (Pothukuchi, 2005). The prevailing notion in the grocery industry has been that suburbs offer safer and more profitable markets, leading to "supermarket redlining" (Crowe et al., 2018; Eisenhauer, 2001). This practice has distanced urban residents, particularly in Black communities, from access to diverse, affordable, and healthy food options, confining them predominantly to convenience stores (Colson-Fearon &Versey, 2022). Even when there is market demand, supermarket redlining creates a scarcity of grocery stores in central urban areas (Crowe et al., 2018).

In 2022, the official poverty rate for Blacks living in America was 17.1% (Schider, 2023). Nam et al. (2015) revealed that economic factors such as income, homeownership, and education determine poverty levels, consequently impacting food security. In contrast, higher income, increased educational attainment, and stable homeownership significantly elevate the likelihood of achieving food security (Nam et al., 2015). These determinants disproportionately affect the Black community (Nam et al., 2015). Financial inequities often force individuals and families within low-income communities to prioritize immediate needs over long-term health, leading to compromised dietary choices and reliance on cheaper, less nutritious options (Nam et al., 2015). Higher grocery prices compound these hurdles (Colson-Fearon &Versey, 2022; Crowe et al., 2018). The rejection of Supplemental Nutrition Assistance Program (SNAP) benefits and limited food options in local neighborhoods prompt residents to seek alternatives in areas less accessible without private vehicles or reliable public transportation (Colson-Fearon &Versey, 2022; Crowe et al., 2018). Safety concerns also deter community members from shopping at local stores, citing encounters with stray animals, navigating unsafe routes at night, perceived threats on public transportation, or harassment from loiterers (Crowe et al., 2018; Cummins, 2005). Collectively, these factors restrict Black individuals' access to local food sources and exacerbate the ongoing struggle for adequate nutrition within these communities (Crowe et al., 2018).

Addressing the entrenched historical and structural barriers underlying food insecurity in Black communities is essential for meaningful change. Despite the enduring influence of economic factors, housing discrimination, and systemic inequalities on food security, urban farming emerges as a potential decentralized solution. Urban farming has positively impacted access to food and community development. In the quest for a more equitable and sustainable food system, urban farming is crucial to fostering resilience and transforming the food security landscape for Black communities.

Urban Farming

Urban farming emerged in its modern form during the 1970s to intertwine social justice objectives with environmental sustainability (Aurora University, 2019). Urban agriculture aims to increase access to healthy, locally grown food, especially for underserved communities (Covington, 2022; Machuka, 2022). Growing and distributing food in urban areas allows for more direct access to fresh vegetables, fruits, and meat products, which can improve food security and nutrition. Initially rooted in community gardens, where residents collectively cultivated small plots of land, urban farming has evolved significantly (Seigner et al., 2018). It now includes rooftop and warehouse farms utilizing unused urban space, hydroponic systems growing plants in nutrient-rich water, aeroponic setups nurturing crops through misting, and aquaponic facilities interweaving aquaculture with hydroponics (Machuka, 2022; Sayner, 2022). This evolution in farming represents a shift towards more efficient and sustainable agriculture methods. In addition, the approaches to urban agriculture help overcome spatial limitations and optimize resource use in densely populated areas (Machuka, 2022).

Benefits

As a decentralized food production system, urban farming yields many benefits, from fostering community empowerment and improved health outcomes to economic sustainability and environmental advantages. Urban agriculture initiatives significantly combat food insecurity and systemic disparities by empowering communities with local food control, promoting self-reliance, and offering tangible solutions for accessing nutritious food (Colson-Fearon &Versey, 2022; Oh & Lu, 2023). Advocates argue that investing in urban agriculture could be more economically viable than attempting to attract supermarkets into neighborhoods (Colson-Fearon &Versey, 2022). The local food economy also benefits as locally grown products are purchased within the city, circulating money within the community, and reducing overall costs due to decreased transportation and preservation expenses (LeJava & Goonan, 2012).

Health outcomes among community members also improve as access to fresh, nutritious produce increases, potentially mitigating health disparities in Black communities (Noonan et al., 2016). Practical experience with fresh food positively influences dietary habits, enhancing overall consumption patterns and nutritional knowledge within Black communities and effectively creating educational hubs that promote nutrition awareness (Colson-Fearon &Versey, 2022; LeJava & Goonan, 2012; Nolet, 2017).

Urban farming creates job opportunities and fosters skill development by providing training and internships for youth and the unemployed (LeJava & Goonan, 2012; Nolet, 2017). Studies have shown that transforming vacant lots into green urban spaces through urban agriculture initiatives reduces crime rates and instills a sense of community pride (LeJava & Goonan, 2012). From environmental and economic perspectives, urban farming significantly decreases transportation distances, reducing greenhouse gas emissions and costs associated with food transportation from various regions (Colson-Fearon &Versey, 2022; LeJava & Goonan, 2012).

Due to urban farms' proximity to customers, urban farms minimize food packaging materials, reduce transportation and storage costs, and reduces global pollution (Kamprad, 2021). Urban farming initiatives mitigate stormwater flows that strain municipal sewage systems by absorbing rainwater into the soil (LeJava & Goonan, 2012). To further minimize the impact of stormwater flow, urban farming utilizes rain barrels and rainwater for irrigation in rooftop gardens. (LeJava & Goonan, 2012) Also, urban gardens and farms contribute to cooler urban temperatures by providing open spaces and vegetation, which regulates excessive local heat (LeJava & Goonan, 2012).

Barriers

Urban farming offers numerous advantages to urban communities and enhances food security; however, its implementation faces barriers such as navigating legal complexities, obtaining start-up funds, acquiring land, overcoming environmental obstacles, and addressing staffing needs. Legal constraints, such as varying regulations imposed by city zoning and homeowners' associations (HOAs), hinder urban agriculture practices (Kopiyawattage et al., 2019). In numerous urban areas, restrictions prohibit commercial agriculture on smaller land plots, the sale

of agricultural produce in residential zones, and the keeping of livestock in residential areas or districts (LeJava & Goonan, 2012; Zambrano-Prado et al., 2021). Understanding and complying with local laws and processes have posed significant challenges for farmers, often leading growers to opt out of practicing agriculture in urban areas due to fears of jeopardizing their businesses (Kopiyawattage et al., 2019).

The scarcity of quality urban land poses a significant obstacle to producing healthy, locally grown food (Machuka, 2023). Dense urban populations leave limited space for agricultural activities, presenting complications for community members and farmers. Acquiring and maintaining suitable, affordable land for urban agriculture becomes difficult in low-income neighborhoods where land ownership may be restricted (Machuka, 2023). Funding challenges are even greater than those of land acquisition. Urban farmers require staffing, seeds, soil, water, and, in some cases, advanced technologies (Machuka, 2023). Limited nonprofit and government funding for these projects can restrict the access to financial support for farming materials and resources, ultimately diminishing crop yields and quality (Kopiyawattage et al., 2019; Machuka, 2023).

Concerns about the environment related to soil and water quality emerge when implementing urban agriculture practices. Urban soils often carry various pollutants, including heavy metals, pesticides, and industrial chemicals (Machuka, 2023). This soil contamination poses health risks for farmers and consumers. Therefore, soil testing before planting is crucial. Soil testing will ensure appropriate measures are implemented to remediate contaminated soils (Machuka, 2023). Additionally, farmers must consider that excessive use of fertilizers, insecticides, and manure can contaminate water sources and potentially seep onto adjacent properties or into local water bodies (LeJava & Goonan, 2012). Water availability poses another challenge. Urban farmers must consider the need to balance the demand for water in urban agricultural settings with the strain it might impose on municipal systems, which are often near capacity (Castilo et al., 2013; LeJava & Goonan, 2012).

A substantial demand for most urban farming initiatives is recruiting and retaining skilled staff or volunteers. A capable workforce with expertise is necessary for the success and sustainability of these projects (Machuka, 2023; Kopiyawattage et al., 2019). Executing food production effectively and efficiently requires significant training (Castilo et al., 2013). For example, when urban soil exhibits low quality, growers may need more expertise to enhance soil health or implement best management practices for irrigation, fertilizer, and pesticide use (Kopiyawattage et al., 2019; Papanek et al., 2023). However, urban growers often need more knowledge regarding production systems, plant lighting, and root-zone environments (Papanek et al., 2023). These knowledge deficits could lead to improper resource allocation, increased costs, and ecological inefficiency within the system. Moreover, obtaining USDA Good Agricultural Practice (GAP) certification is often required for selling food through many distribution channels, ensuring food safety is a priority (Castilo et al., 2013). Unfortunately, many growers remain unaware of the required certifications and government regulations. The distance between training centers and local communities further compounds the issues of obtaining certifications

and abiding by government regulations, further hampering the success of urban farming and food distribution (Castilo et al., 2013; Papanek et al., 2023).

Urban Farm Initiatives in the United States

In response to the growing need for sustainable food sources in urban landscapes, various innovative initiatives and organizations have emerged. These range from community-driven rooftop gardens and neighborhood cooperatives to mission-centric for-profit enterprises utilizing hydroponic and aquaponic systems. However, there remains a noticeable gap in research regarding the impact of these urban farming initiatives on Black communities. Despite this limitation, these initiatives demonstrate the success and positive impact of urban farming, epitomizing resource efficiency and a shared commitment to transforming urban food landscapes and providing healthy, affordable food for those with limited access.

Growing Power

In 1993, professional basketball player and son of sharecroppers William Allen bought the last remaining farm in Detroit, Michigan, located 4 miles from the nearest grocery store and five blocks from the closest public housing projects (Hagey et al., 2012; Satterfield, 2018). Allen then created a national nonprofit and land trust organization, Growing Power, which provided northern Milwaukee communities with better access to healthy, high-quality, affordable food and fostered a more sustainable, equitable food system (Hagey et al., 2012; Satterfield, 2018). Growing Power's programmatic focus was composting and youth mentorship (Satterfield, 2018). Allen began this project with wood garden beds and later added aquaponics (Hagey et al., 2012; Satterfield, 2018). This project eventually grew to 14 greenhouses, livestock pens, and hoop house stands filled with salad greens, arugula, beets, tilapia, perch, beehives, hens, ducks, goats, and turkeys (Hagey et al., 2012). A defining characteristic of Growing Power was the holistic feedback loops of the farm (Satterfield, 2018). The organization produced food using a sophisticated, organic system that relied on recycled waste from local restaurants, breweries, farms, coffee houses, and worms to help generate nutrient-rich compost that helped crops thrive (Satterfield, 2018). Growing Power distributed the food and refurbished soil to retail stores, restaurants, farmers' markets, schools, and a community-supported agriculture program (Satterfield, 2018). In addition, decorative plants were used for landscaping and then sold to schools and community centers, funding the program's continuation (Satterfield, 2018).

Growing Power worked with the local juvenile justice system, training, and rehabilitating children by planting flowers in vacant lots, whereby, according to Allen, they might have otherwise been used for selling drugs (Satterfield, 2018). The organization began fostering schools and community gardens throughout the city. Students learned how to read, write, and grow vegetables (Satterfield, 2018). In the early 2000s, the farm became a training facility providing training, outreach, and technical assistance to share its knowledge with visitors worldwide (Satterfield, 2018). By 2009, Growing Power was selling food online, at farmers' markets, schools, restaurants, and in below-market community-supported agriculture boxes, reaching more than 10,000 people (Hagey et al., 2012; Satterfield, 2018). Growing Power created various training programs–leadership programs, job trainings for underserved youth,

internships, and hands-on workshops—which spread exponentially throughout the region (Hagey et al., 2012; Satterfield, 2018). The funds also supported a Chicago chapter of Growing Power, led by Erika Allen, Will Allen's daughter (Satterfield, 2018). Despite its many successes, Growing Power faced financial, organizational, and legal challenges (Satterfield, 2018). As a result, Growing Power's board of directors voted to dissolve the organization in 2017 (Satterfield, 2018).

City Slicker Farms

City Slicker Farms (CSF) is an urban agriculture organization rooted in West Oakland dedicated to fulfilling the community's need for fresh, affordable food. Founded in 2001 by Willow Rosenthal, a food justice advocate, the organization primarily focused on cultivating food on borrowed land (California FreshWorks, 2022; Mann, 2021). Since its inception, CSF has established over 550 backyard gardens and community farms, yielding an annual harvest of over 30,000 pounds of fresh produce (Mann, 2021). CSF initiated weekly farm stands to ensure equitable access, offering produce on a pay-what-you-can basis (California FreshWorks, 2022). Moreover, as a vital part of their food justice initiative, City Slicker Farms conducted comprehensive training programs for youth and adults, empowering them with the skills to grow and cook their food (California FreshWorks, 2022). This effort forged a network of school, community, and backyard gardens and gardeners, nurturing a self-sustaining cycle of food sovereignty (California FreshWorks, 2022). However, the lack of a permanent piece of land meant the organization had to periodically dig up and relocate some of their garden plots (California FreshWorks, 2022). In 2010, CSF received a $4 million grant from the California Department of Parks and Recreation (California FreshWorks, 2022; Mann, 2021). This grant aimed to develop protected green spaces in underserved communities with the stipulation that the designated area had to include a public park (Steinberger, 2015). This grant facilitated the purchase and development of a 1.4-acre brownfield lot, marking the establishment of the West Oakland Farm Park in 2012 (California FreshWorks 2022; Mann, 2021; Steinberger, 2015).

The West Oakland Farm project faced financial hurdles as CFS had difficulty managing a $4 million project with an annual budget of under $500,000, land acquisition and construction expenses, and guidelines associated with grant funds (California FreshWorks, 2022). With the support of the Nonprofit Finance Fund (NFF), CSF received a bridge loan, which enabled the organization to manage the reimbursement intricacies of the State grant (California FreshWorks, 2022). Since 2016, the West Oakland Farm Park has become a hub, offering locally sourced food, educational programs for youth, and collaborative workday initiatives for other organizations (Mann, 2021). The community's vision has manifested in various facets: an outdoor classroom dedicated to urban agriculture education, a nutrition demonstration zone, a market farm, a community garden supporting 28 families, and additional features such as an orchard, a greenhouse, shade structure, a chicken coop, and beehives (California FreshWorks, 2022; Steinberger, 2015).

Gotham Greens

In 2011, a group of entrepreneurs—Viraj Puri, Eric Haley, and Jenn Frymark—founded Gotham Greens in Brooklyn, NY (Manning, 2021; Sustainable Urban Delta, 2021). This venture emerged from two co-founders recognizing the extensive travel distance of fresh produce from farm to table. After subsequent research, Puri and Healy discovered that nearly 98% of fresh produce in the United States is grown in California or Arizona and travels thousands of miles to its destinations, often resulting in food waste as well as a negative impact on the environment through increased carbon emissions (Taranshansky, 2023). Motivated by this insight, Puri, Haley, and Frymark identified a need and purpose: to establish farms closer to where people reside to promote access to quality, fresh, affordable food year-round (Taranshansky, 2023).

Today, Gotham Greens consists of 13 high-tech, climate-controlled, data-driven hydroponic greenhouses totaling more than 40 acres in California, Colorado, Georgia, Illinois, Maryland, New York, Rhode Island, Texas, and Virginia (Taranshansky, 2023; Sustainable Urban Delta, 2021). Their sustainable farming methods use up to 95% less water and 97% less land than conventional farming and eliminate agricultural runoff (Taranshansky, 2023). The Gotham Greens' product line encompasses an array of fresh greens, herbs, salad dressing, and sauces (Manning, 2021). Gotham Greens' retail practices have kept the company afloat, especially during the COVID-19 pandemic when the food service business was not as profitable (Manning, 2021). Products primarily reach consumers through local markets, grocery chains, and restaurants, fostering a direct connection between urban agriculture and the communities it serves (Manning, 2021).

As a mission-driven company, Gotham Greens has focused on creating jobs for residents. In addition, they have partnered with schools, community gardens, nonprofits, and businesses to provide healthy food to those in need through environmental, educational, and community initiatives (Sustainable Urban Delta, 2021; Taranshansky, 2023). In 2022, they donated over 44,000 pounds of food to families in need and provided more than 27,000 seedling donations for community gardens and educational purposes (Taranshansky, 2023). The company's newest endeavor includes a research partnership with the University of California, Davis, to research all aspects of the indoor and urban agriculture industries (Manning, 2021).

Atlanta's Community Urban Food Forest at Browns Mill Park

At the start of 2021, the city of Atlanta opened its first Community Urban Food Forest (CUFF) within Browns Mill Park to address the pressing needs of a food desert (Landau, 2021). This initiative aligned with AgLanta (a program in Atlanta, Georgia, focused on promoting urban agriculture and sustainable food systems in the city) and the City of Atlanta's Mayor Office of Resilience objectives, intending to drive urban agriculture strategies, engage residents, foster community involvement, and highlight economic prospects for local enterprises. (Landau, 2021). CUFF is the largest public food forest (eg.an agroforestry system that mimics the structure and functions of a natural forest ecosystem but is designed primarily to produce food) in the nation, spanning 7.1 acres (The Conservation Fund, n.d.). It was once a functional family farm where the original owners provided produce to local community members (The Conservation Fund, n.d.). It

is a thriving seven-layer ecosystem (e.g. canopy, understory, shrub, herbaceous, ground cover, rhizosphere, vertical layers) cultivating medicinal herbs, vegetables, and fruits (The Conservation Fund, n.d.). This multi-tiered forest supplies an array of produce, addressing the food needs of community members, especially those lacking easy access to fresh and nutritious options (Eccles, 2021).

In cooperation with organizations such as The Conservation Fund and the Greening Youth Foundation, CUFF has maintained and expanded this community-driven concept. CUFF has introduced a workforce development program, providing participants with stipends and comprehensive training in practical and technical skills. This initiative aims to equip individuals for potential employment in the green sector while focusing on agricultural and environmental education for all ages (The Conservation Fund, n.d.). This innovative initiative is poised to deliver enduring advantages for nearby communities, ensuring equitable access to sustenance and fostering long-term community well-being (The Conservation Fund, n.d.).

Urban farming initiatives like Growing Power, Gotham Greens, City Slicker Farms, and Atlanta's Community Urban Food Forest at Browns Mill Park contribute significantly to food security in Black communities. They employ diverse approaches, ranging from community-driven models to high-tech hydroponic systems and expansive food forests. While all initiatives have shown success, Gotham Greens, City Slicker Farms, and Atlanta's Community Urban Food Forest have sustained longevity due to diverse funding and sustainable business models. The premature dissolution of Growing Power emphasizes the need to address financial, organizational, and legal hurdles for sustainability. Learning from setbacks and actively supporting urban farming programs is crucial for lasting impacts on food security and community well-being. Successful models set a precedent, encouraging more start-ups and initiatives to explore diverse funding streams and sustainable practices. However, closures serve as cautionary tales deterring communities from implementing initiatives and highlighting the need for reevaluation within the sector. The resilience and innovation of these initiatives demonstrate the potential of urban farming to transform food landscapes and improve the lives of individuals and communities.

Unlocking Potential: AI Integration in Urban Farming

The exploration of artificial intelligence (AI) and its integration into urban farming can be pivotal to understanding innovative agricultural practices. While urban farming initiatives have been essential in enhancing food security within Black communities, integrating AI introduces a new dimension to the agricultural landscape. Comprehending the intersection of AI and urban farming involves investigating how advanced technologies, traditionally associated with conventional agriculture, hold the potential to fortify food security in urban settings.

AI and Traditional Farming

Traditional farming, typically conducted on vast rural land far from densely populated urban centers, is distinct from urban farming but provides valuable insights. Technological

advancements applied in traditional farming methods can serve as a blueprint for innovating urban farming practices.

Advanced technology has reshaped farming practices as the demand for increased food production escalates (Wipro, 2019). Researchers, farmers, and agricultural companies are actively exploring new methods, such as Artificial Intelligence (AI), to boost production while curbing waste (Wipro, 2019). In 2021, approximately 87% of agriculture companies used AI technology on farms (Bassett, 2023). AI-driven solutions exhibit the potential to enhance efficiency, augment production volumes, and elevate overall quality (Wipro, 2019). Furthermore, AI's predictive capacities enable proactive measures against crop diseases, pests, and adverse weather conditions, ultimately safeguarding harvests (Talaviya et al., 2020). The following AI applications encompass a spectrum of technologies that have revolutionized traditional farming practices to date:

- **Precision farming** optimizes resource utilization by precisely administering water, fertilizers, herbicides, and pesticides, thus minimizing waste, and enhancing crop yields (Dongre, 2023; Javaid et al., 2023; Talaviya et al., 2020). For instance, AI sprayers significantly reduce chemical volume and herbicide expenditure, improving agricultural produce quality and cost efficiency (Wipro, 2019).
- **Crop monitoring systems** powered by AI in conjugation with sensors, drones, and satellites, offer real-time insights into crop health, facilitating early detection of diseases, nutrient deficiencies, or pest infestations (Javaid et al., 2023; Talaviya et al., 2020).
- **Predictive analytics** leverage machine learning algorithms to forecast weather patterns, disease outbreaks, yield estimations, and assist farmers in proactive decision-making (Javaid et al., 2023; Talaviya et al., 2020).
- **Smart machinery and robotics** integrated with AI capabilities streamline planting, harvesting, and sorting tasks, heightening efficiency and reducing labor requirements (Javaid et al., 2023; Talaviya et al., 2020).
- **Decision support systems** analyze complex datasets, offering tailored recommendations for planting schedules, irrigation strategies, and more (Javaid et al., 2023; Talaviya et al., 2020).

AI enhances farmers' access to valuable market intelligence. AI-powered tools provide critical market insights, pricing trends, and demand forecasts, empowering farmers to strategically decide crop selection and sales strategies (Dhanaraju, 2022; Kewte, 2023). These insights bolster farmers' ability to optimize yields and navigate competitive markets effectively (Dhanaraju et al., 2022; Kewte, 2023). Additionally, AI facilitates educational advancements by offering learning platforms that equip individuals with skills in technology, data analytics, and sustainable farming practices, thereby expanding opportunities and fostering economic resilience within agricultural communities (Kewte, 2023).

As separate initiatives, urban farming and AI practices in traditional farming have increased access to food, reduced food waste, and positively impacted the environment. Artificial intelligence combined with urban farming holds promise in advancing existing advantages,

refining agricultural methods, and contributing to equity by decentralizing food production (Steenkemp et al., 2021). Within Black communities, the integration of AI in urban farming holds the promise of optimizing resource utilization, increasing productivity, and bolstering food security. However, while these AI-driven practices offer benefits, they also introduce challenges and disparities. Understanding the opportunities and challenges in promoting sustainable and equitable food systems can provide valuable guidance for individuals seeking to engage in urban agriculture initiatives and navigate AI adoption.

Use of AI Technology in Urban Farming Methods

Like AI technology in traditional farming methods, AI can span various aspects of urban farming, from crop sowing and livestock monitoring to product distribution. Techniques like data-driven decision-making and crop planning utilize agricultural data to optimize crop selection, planting schedules, and resource allocation, aiding growers in informed decision-making (Javaid et al., 2023; Talaviya et al., 2020). Machine learning applications analyze plant responses, enabling customized growing strategies. These algorithms also analyze genetic data to develop resilient and productive plant varieties resistant to pests, diseases, or environmental stressors (Javaid et al., 2023; Talaviya et al., 2020). Moreover, automated farming processes that employ AI-powered robots and systems for every step of the growing and distribution processes, can lead to reduced labor costs and constant crop monitoring and management (Talaviya et al., 2020).

There are many opportunities for advancement in crop monitoring through AI. For instance, indoor vertical farming leverages AI algorithms to analyze light, temperature, nutrient levels, and humidity data (Oh & Lu, 2023). These insights facilitate adjustments to LED lighting and climate control systems, optimizing conditions for plant growth within confined vertical spaces (Oh & Lu, 2023). This precision-driven approach ensures optimal conditions for robust plant growth and fosters higher yields within limited urban settings (Dongre, 2023; Javaid et al., 2023; Talaviya et al., 2020). Precision agriculture capitalizes on data from sensors, drones, and satellites to monitor crop health, soil moisture, and nutrient levels (Javaid et al., 2023; Talaviya et al., 2020). This information aids in precise irrigation, fertilization, and pest control, effectively utilizing resources and maximizing crop productivity.

Urban farmers can proactively use predictive analytics to address disease, pest detection, and crop management. Disease detection and management employs AI-powered image recognition systems to identify plant diseases or nutrient deficiencies by analyzing images of leaves or crops (Javaid et al., 2023; Talaviya et al., 2020). Early identification allows for timely intervention and treatment, mitigating potential damages. Predictive analytics in pest management use historical and real-time data to forecast pest outbreaks. Proactive approaches enable urban farmers to anticipate issues and execute targeted interventions, reducing pesticide use and minimizing crop damage (Talaviya et al., 2020). AI-integrated automated irrigation systems use sensors and algorithms to deliver precise amounts of water at optimal times, minimizing waste and ensuring ideal hydration for crops within urban environments (Javaid et al., 2023; Talaviya et al., 2020). AI-powered robotics with advanced machine vision and manipulation capabilities can improve

harvesting tasks' precision and efficiency in urban farming setups (Talaviya et al., 2020). Similarly, AI algorithms are instrumental in supply chain optimization, accurately predicting demand, managing inventory, and orchestrating efficient transportation routes (Javaid et al., 2023; Talaviya et al., 2020). AI-driven systems track and manage food waste by monitoring consumption patterns, optimizing inventory, and proposing viable options for donation or recycling. This minimizes waste and ensures the quick delivery of fresh produce to consumers.

The use of AI extends beyond crops, as it also benefits livestock monitoring. Like in crop management, predictive analytics can control diseases among animals. AI can forecast and preempt potential disease outbreaks by using historical data on disease outbreaks, weather patterns, and animal health (Electric Solenoid Valves, 2023). AI-powered sensors and monitoring systems prioritize the health of animals by tracking vital signs, behavior patterns, and health metrics (Neethirajan, 2023). Real-time analysis of this data helps identify early signs of illness or distress, facilitating timely intervention and treatment (Neethirajan, 2023). Feed management can also benefit from AI algorithms that optimize feed formulation tailored to nutritional requirements, growth stages, and health conditions (Neethirajan, 2023). Algorithms can predict optimal breeding times for better reproductive outcomes. Automated monitoring and control systems regulate environmental factors such as temperature, humidity, and ventilation in livestock housing (Electric Solenoid Valves, 2023). The use of AI technology allows the farmer to control and ensure optimal living conditions for livestock by observing the actions of animal behavior patterns, detecting signs of stress, discomfort, or irregular behavior (Neethirajan, 2023).

Barriers to Implementation and Utilization

While AI has promising impacts, introducing advanced technology in urban farming may amplify the existing challenges linked to implementation and utilization. Like traditional farmers, Black urban farmers face disproportionate challenges due to barriers hindering the adoption of traditional and urban farming methods. The upfront costs of launching urban farming initiatives can create barriers, particularly for individuals and communities with limited financial resources (Hutchison-Everett, 2023). Investing in AI technology can increase farmers' overhead expenses, increasing the selling price of food items to offset costs. Some farmers said that the potential increase in food prices deterred them from considering AI technology because they wanted to continue to provide affordable food to the community. These challenges contribute to urban farmers' difficulty to conceptualize or identify the benefits of investing in AI technology, thereby constraining their willingness to investment.

In addition to the cost of AI technology and other resources, Black farmers are skeptical about using and trusting essential AI software and machinery. Black farmers fear being surveilled and tracked (Davis & Love, personal communication, January 17, 2024). These concerns indicate that limited access to AI education and training could impede the adoption of AI in urban farming initiatives currently operating in Black communities. An inability to utilize AI software and machinery can exacerbate the technological divide, particularly when other communities leverage advanced technologies to enhance food accessibility. This disparity may hinder and further marginalize Black communities without access to or knowledge of innovative agricultural

technologies. The technological gap, combined with limited agricultural experience, financial challenges, and fears, may discourage community buy-in, which is necessary as it directly impacts the implementation of urban farming or other community-based initiatives.

Benefits of Implementation

Research (Brown & Jameton, 2000; George, 2013; Gripper, 2023; Lejava & Goonan, 2012; Noonan, 2016) indicates that establishing urban farming initiatives in Black communities has the potential for many positive outcomes, such as enhanced physical and mental health, increased employment, educational prospects, community resilience, and reduced crime rates. Integrating AI technology increases the chances of achieving these outcomes by streamlining farming practices, optimizing resource management, boosting yield, and curtailing waste and harmful chemicals. Researchers propose that elevated food yields in communities lacking healthy food sources translate to improved access to affordable food and nutrition (Seigner, 2018). Similarly, using AI in urban farming methods can produce healthier food by reducing the number of pesticides used on crops and preventing the growing of produce in contaminated areas (Wipro, 2019). Safe, nutritious food options address immediate food needs and present opportunities to educate residents on healthy dietary habits (United States Department of Health and Human Services [HHS]; n.d.). In addition, access to healthier food choices and knowledge is a catalyst for improved health outcomes, which is important for the Black community since they are often disproportionately impacted by prevalent chronic illnesses like heart disease and diabetes impacted by nutrition (HHS, n.d.). AI utilization within urban farming practices also contributes to improving air quality. Innovative AI-powered techniques, such as vertical farming, introduce green spaces and mitigate the carbon footprint associated with long-distance produce transportation (Taranshansky, 2023). The potential improvement in air quality specifically benefits Black communities by reducing respiratory ailments such as asthma, which disproportionately affects Black children (Office of Minority Health; n.d.).

Urban farming initiatives incorporating AI technology allow for economic growth and educational advancement within the Black community. Using AI in urban farming opens doors for innovation and entrepreneurship. Community members can create innovative AI tools or systems designed to meet urban farming requirements. There is also the possibility of creating AI-powered urban farms owned and operated by Black individuals. Black-owned urban farms established in Black communities can create job opportunities for community members. AI integration in urban farming can create new roles beyond traditional farming skills. For example, individuals skilled in or willing to learn about technology, data analysis, and AI management would have opportunities to be employed in AI system maintenance, data analysis, precision farming, and software development. Introducing technology into urban farming practices presents a promising avenue to capture the attention and enthusiasm of the younger Black generation, which has shown little interest in farming and the agriculture industry, in part due to experiences of trauma, physical and economic struggles, and a perceived lack of return on investment (Davis & Love, personal communication, January 17, 2024).

Many urban farms serve as educational hubs for community members. Incorporating AI technology into urban farming methods can expand the education potential of urban farms by introducing school-aged children to AI, STEM, and technology, as well as internships for teenagers and adults. Furthermore, initiatives to integrate AI into farming within Black communities often require community organizers, coordinators, and outreach specialists. These roles focus on community engagement, ensuring the technology is effectively used and benefits all community members. Increased access to education, job opportunities, green spaces, and food necessities can also decrease crime rates within urban and low-income communities (U.S. Department of Justice, 2011).

Consequences of Implementation

It is crucial to address potential drawbacks in the implementation of urban farming programs. Gentrification emerges as a significant concern due to its historical impact on Black residents in urban areas targeted by farming initiatives. Some urban farming projects, by enhancing green spaces and fostering businesses, have demonstrated the capacity to raise property values, potentially contributing to displacement (McClintock, 2008; McClintock et al., 2018). The integration of advanced technology by technology companies in urban settings may attract higher-educated homeowners, reshaping demographics and displacing lower-educated renters (Qian, 2022). While neighborhood development can positively change Black communities, carefully considering the effects of increased business activities, green space introduction, and technological advancements is essential. The incorporation of AI technology in urban farming, while holding promise, poses the risk of unintended consequences, including potential displacement of Black residents and undermining the intended benefits of improved food access, job opportunities, and a safer environment.

Introducing high-tech jobs through AI technology may not necessarily benefit Black urban residents as individuals with more technology and work experience may not come from the local community. This challenges the assumption that new job opportunities will be accessible to Black residents. Additionally, integrating AI into urban farming changes the skill requirements, diminishing the demand for traditional farming expertise. This shift further limits job availability for the community, as fewer individuals with traditional farming experience may find opportunities within the evolving landscape of urban farming initiatives.

Biases in AI algorithms also present a challenge when implementing AI technology in urban farming programs. AI algorithms are created by humans who possess unique biases and draw from historical datasets and research (Leffer, 2023). AI algorithms may inherit biases present in the data used to train them. If the datasets used do not adequately represent the knowledge and diverse needs of Black communities, there is a risk of perpetuating existing disparities for growers and consumers. If the training data favors certain crops, it could lead to inaccurate harvests or the reduction of culturally significant or locally preferred crops.

Integrating AI technology in urban farming operations can cause overreliance on systems for crop management, irrigation, and monitoring tasks. While AI can enhance efficiency, there is a

risk of vulnerability if the technology faces disruptions or malfunctions. In the event of technical difficulties, the farm's operations could be severely impacted, potentially leading to reduced crop yields, financial losses, and challenges meeting community needs for fresh produce. This dependency on technology underscores the importance of implementing robust contingency plans, ensuring resilience against technical failures, and providing adequate training for community members to address minor issues.

Policy Recommendations

Enact the Justice for Black Farmers Act. In the 118th Congress (2023-2024), Representative Alma Adams (D-NC) and Senator Cory Booker (D-NJ) reintroduced this crucial legislation. The proposed bill aims to rectify the historical discrimination faced by Black farmers and ranchers, necessitating reforms within the Department of Agriculture to prevent future injustices. The legislation encompasses various provisions, including establishing a Farm Conservation Corps to equip young adults from socially disadvantaged groups with the skills essential for careers in farming and ranching. Additionally, it allocates funding for historically Black colleges and universities (HBCUs) to initiate and expand courses focused on agriculture or related disciplines. Furthermore, the legislation (a) addresses issues related to farmland ownership and succession; (b) expands credit assistance for socially disadvantaged farmers and ranchers, boosts funding for the Local Agriculture Market Program; and (c) prioritizes socially disadvantaged farmers and ranchers for conservation technical assistance, the Conservation Stewardship Program, and the Rural Energy for America Program. While this legislation specifically focuses on addressing historical and ongoing discrimination against Black farmers in rural areas, some provisions of the act (i.e. increasing access to land, providing funding for agricultural education, supporting sustainable farming practices, credit assistance and funding for local agriculture programs) could indirectly benefit urban farmers as well. The broader goals of addressing systemic inequalities in agriculture could have positive implications for urban farming too.

Prioritize increased investments in public housing initiatives and affordable housing programs. Public housing and affordable housing programs offer housing solutions for eligible low-income individuals and families. By strategically investing in these programs, both the U.S. Department of Housing and Urban Development and local governments can address housing needs and allow families to allocate more of their income to food. Expanding qualification criteria for these programs can ensure that residents who rent their homes can remain in the community even amidst urban farming initiatives that lead to potential development or other investments. This approach is designed to prevent the displacement of long-standing community members who were there before the implementation of new projects.

Implement property tax breaks or sustain property tax fees for low-income areas where urban farming initiatives are introduced. Introducing property tax breaks or maintaining affordable property tax fees in low-income areas is a potential solution to support communities experiencing or vulnerable to gentrification due to the introduction of urban farming initiatives. This policy would alleviate the financial burden on current residents in evolving neighborhoods,

ensuring that community members can continue to afford their homes despite the local real estate landscape changes. This protective measure counteracts displacement and ensures that existing residents withstand the changes and benefit from the positive development within their community.

Implement flexible zoning regulations to permit crop expansion, cultivation, and distribution on non-commercial land within Black and low-income communities. Local governments should enact community land-use zoning policies to expand designated areas suitable for agricultural development, particularly within urban settings. These policies should also incorporate distribution regulations that empower growers to sell and distribute their products to community members efficiently.

Enhance access to fair and non-predatory lending options. Historically, Blacks have faced systemic challenges, including denied loans and the imposition of predatory terms for personal and business financing. Many Black farmers have described struggling to maintain their land and businesses hindered by a lack of financial resources. Banks and farm loan agencies offering equitable lending options empower traditional and urban Black farmers to establish and sustain their enterprises but also contribute to the reversal of the decline in Black farmers in the United States. Additionally, fair lending practices facilitate the provision of affordable, nutritious food to Black communities.

Design curricula integrating AI and cutting-edge technology within agricultural studies at colleges and universities. In the United States, 213 colleges and universities offer agriculture degrees and courses. Universities should enrich their curricula with AI education to benefit students pursuing agricultural careers and entrepreneurship post-graduation. Implementing modules that focus on machine learning, computer vision, robotics, and data analytics specifically tailored to agricultural contexts is essential. This can be achieved through collaboration across departments such as agricultural science, engineering, computer science, and data science. Proficiency in technology and agriculture is crucial for farmers and employees implementing AI-powered urban farming initiatives. Additionally, older Black farmers express uncertainty about whether younger generations will embrace farming due to perceived challenges in labor and profitability. Introducing younger individuals to how advanced technologies can benefit and be profitable in agriculture contributes to increasing the number of Black farmers in the United States.

Intensify research efforts to explore the challenges confronting Black farmers and growers, along with the influence of AI on their agricultural practices. While research indicates the advantages of incorporating AI technology into conventional farming methods, there is a notable underutilization of these innovations among Black farmers. A research gap exists, specifically in studies exploring and evaluating the implementation of AI in both traditional and urban agriculture for Black farmers and the broader Black community.

Create government-backed agricultural infrastructure funds. Government agencies and private organizations should invest in constructing and operating community-based agricultural infrastructure. Establishing dedicated funds that prioritize the development and upkeep of agricultural facilities, including processing centers and storage facilities, with a specific emphasis on affordability for Black agricultural entrepreneurs, is paramount. This approach ensures that Black urban farmers secure the necessary funding for start-up costs and sustain their businesses effectively.

Establish affordable agricultural land trusts. The establishment of Affordable Agricultural Land Trusts, explicitly focusing on acquiring and preserving land for Black urban growers and traditional farmers, can be achieved by allocating public funds. This initiative ensures that Black growers have the necessary resources to acquire and manage affordable agricultural land.

Promote workforce diversity in technology companies. To reduce biases in AI software and machinery, tech companies must prioritize diversity in their workforce. Technology companies must make a concerted effort to recruit, hire, and train employees from diverse backgrounds.

Conclusion

Black communities continue to bear a disproportionate burden of food insecurity, a consequence of systemic issues such as racism, poverty, and divestment in low-income areas. The impact of an individual's access to food and experiences with hunger extends to their health outcomes, financial stability, and overall livelihood. In addressing this challenge, urban farming emerges as a transformative technique, particularly in underserved communities. Successful urban farming initiatives, including Growing Power, City Slicker Farms, Gotham Greens, and the Atlanta Food Forest, have effectively heightened access to nutritious and affordable food while fostering community education. Advanced technologies, like vertical and hydroponic farming methods, showcase innovation in action. Similar to farming innovation, Artificial Intelligence (AI) has great potential to amplify crop yields, reduce costs, and mitigate environmental pollution in agriculture. Much like their traditional counterparts, urban farmers face formidable hurdles in acquiring land, accessing capital and resources, and securing essential loans and funding—obstacles that impede the successful establishment or sustainability of growing initiatives. Of particular concern is the disproportionate impact of these challenges on Black growers compared to their white counterparts, considering that only 1% of farmers in the United States identify as Black. Compounding these difficulties, urban farmers may encounter obstacles in adopting AI practices due to a lack of knowledge and accessibility to AI-related materials. A critical research gap exists in exploring the experiences of Black farmers with advanced technology and AI-driven methods. This void underscores the urgency for a comprehensive exploration of AI's impact on traditional Black farming and urban farming within Black communities. Gaining insights into how AI adoption intersects with traditional and urban agricultural methods becomes imperative in addressing challenges, identifying opportunities for urban growers, and advancing food security through targeted policies and programming.

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