CULTIVATING CHANGE: ANALYZING THE GEOSPATIAL DYNAMICS OF URBAN AGRICULTURE AND THE CORRESPONDING DEIJ IMPLICATIONS IN PORTLAND, OREGON

by

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The discourse within the field of environmental science has been heavily dominated by discussions of mounting global crises stemming from growing urbanization. Downstream ramifications include food insecurity, the depletion of natural resources, and environmental concerns. As urbanization increases and access to rural land decreases, new solutions to ameliorate these issues become increasingly urgent. In response to these formidable concerns, urban agriculture (UA) is one potential solution that has grown in popularity. This thesis explores the premise of UA through a literature review that summarizes current research on the relevance, global trends, and its connection to the three pillars of sustainability—social, economic, and environmental. Building on this research, this study identifies a gap in knowledge associated with UA and diversity, equity, inclusion, and justice (DEIJ) implications. To address this, a case study is conducted in the neighborhoods of Portland, Oregon using ArcGIS Pro to assess UA's impact on DEIJ from a racial, economic, accessibility, and environmental perspective. The results indicate that from a racial and ethnic standpoint, UA in Portland is located in primarily ethnically diverse neighborhoods. Relying on data exposing the median household income in Portland neighborhoods, UA is also determined through an economic outlook to be most prevalent in less affluent regions. To evaluate inclusion, it is found that UA

plots are primarily accessible to the general public. Finally, from an environmental outlook, the distribution of UA is located typically in neighborhoods experiencing higher risk factors displayed by both the environmental hazard index and the urban heat island (UHI) index. Based on the findings from the literature review coupled with the data from the case study, it is concluded that Portland upholds many of the DEIJ principles through the implementation of UA. However, many of these issues have complexities that require future research regarding the long-term impacts between UA and DEIJ.

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Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

Overview

Mounting global crises stemming from increasing urbanization dominate the discourse within environmental science fields. Downstream ramifications include food insecurity, the depletion of natural resources, and environmental concerns. In response to these daunting issues, myriad solutions have been determined. One potential solution that continues to rise as a popular method to mitigate these issues is urban agriculture (UA). From the ancient "Hanging Gardens" attributed to the Assyrian King Sennacherib in 700 BCE to its contemporary practice by over eight hundred million people worldwide, UA has become a widespread practice that could alleviate these pressing concerns (Dalley, 1993; Orsini, 2013). While numerous differing definitions and types of UA have evolved over this extensive time period, a comprehensive and inclusive interpretation of UA refers to it as, "...the cultivation, processing, and distribution of both food and non-food plant and tree crops, as well as the rearing of livestock, directly serving the urban market, whether within the urban core or on its periphery" (Mougeot, 2006). By keeping it broad, this definition can encompass varying scales and forms of UA including but not limited to community gardens, urban farms, roof-top gardens, and eco-roofs (Wadumestrige et al., 2021).

To countless people, the concept of agriculture and farming invokes thoughts of spacious, irrigated fields designed for large-scale production. However, rising projections indicate the global population to be 9.8 billion by 2025 with 68% of people residing in urban areas (Galea et al., 2019; Huang, 2019; Satterthwaite, 2007). As urbanization increases and access to rural land decreases, it becomes imperative to recognize the potential and issues within UA and its growing necessity in the changing world (Galea et al., 2019; Huang, 2019; Satterthwaite, 2007). Current research on UA heavily emphasizes its impact on the three pillars of sustainability: societal, economic, and environmental (Ackerman et al., 2014; Specht et al., 2014). Since there are both advantages and disadvantages to UA, it is essential to assess both sides–the benefits and drawbacks–of integrating UA to determine the sustainability impact of agriculture into urban areas (Deelstra and Girardet, 2000; Birch and Wachter, 2008).

Furthermore, gaining recognition as a potential remedy that could delay or possibly reverse some of the issues that plague the planet, UA has become a heavily contested debate in the scientific community. As mentioned, numerous studies delve into the direct physical aspects and significance of UA, including the intricate social, economic, and environmental dimensions that affect the communities implementing UA. However, it is also important to assess how the placement of UA is impacting diverse urban communities in addition to how it addresses these sustainability concerns. By critically analyzing the role of UA in promoting diversity, equity, inclusion, and justice (DEIJ) within nonrural environments, this thesis examines the transformative potential of DEIJ-focused agricultural practices in shaping more resilient and sustainable urban futures for the people within these cities.

Purpose of Study

The purpose of this study is to introduce a distinct lens to observe and understand UA and its growing relevance in this rapidly changing world. This thesis will provide a thorough literature review and synthesis that delves into existing knowledge concerning the presence of UA: the recent surge in UA initiatives, global trends in UA research, and the role UA plays in sustainability efforts.

After synthesizing the current literature and knowledge surrounding UA, this thesis will examine the geospatial distribution of UA plots within a specified urban environment. Based on its relevance and proximity as well as its consistent focus on promoting sustainability, Portland, Oregon is an ideal case study to analyze UA in an urban setting. Coupling the spatial data and demographic data of Portland, this paper will analyze the impacts of UA through a less explored lens: a DEIJ-centric perspective. This analysis will encompass a range of DEIJ aspects, including racial demographics, average household income, the distinction between private and public plots, and environmental health indicators. Thus, through this approach, the study contributes to a deeper understanding of the intricate dimensions of UA and the DEIJ considerations necessary for creating more diverse, equitable, inclusive, and sustainable urban environments.

Significance of Study

Bridging the gap between academic research and real-world practice, the significance of this study lies in its ability to assess the advantages and disadvantages of UA within a city, recognize its impact on minoritized communities, and spread knowledge that could foster inclusive and sustainable urban food systems. Assuming Portland has been successful in implementing UA in DEIJ-considerate locations, this study will offer a blueprint for other cities featuring actionable insights and recommendations for harnessing the potential of UA. Thus, by emphasizing the importance of understanding UA's attributes, this research contributes to ongoing efforts to create more resilient and sustainable cities for future generations while also contributing to the advancement of scholarly knowledge in the fields of environmental science, urban planning, and sustainable development. Ultimately, by highlighting the importance of understanding UA plot placement regarding DEIJ components, the study underscores the potential of UA to serve as a catalyst for positive social and environmental change.

Research Questions and Hypotheses

Overarching Research Questions

1. What is the spatial distribution of UA in Portland, Oregon, and how does it support or obstruct DEIJ principles?

Specific Research Questions

1. With a direct focus on the racial and ethnic demographic, income inequality, access to agriculture, and environmental benefits, does the spatial distribution of UA plots within the neighborhoods of Portland, Oregon support DEIJ efforts?
2. If there are disparities in the distribution, accessibility, and availability of UA plots within Portland when analyzed based on DEIJ factors, how do these disparities contribute to or mitigate existing inequities?

Hypothesis

Hypothesis: It is hypothesized that, compared to places with less UA plots, it is expected that areas with a higher concentration of UA plots will show increased racial and ethnic variety, decreased income inequality, better access to agricultural resources, and improved environmental advantages.

Scope and Delimitations

In the data collection process, this study relies on the 2020 American Community Survey 5-year data at the tract level and the open data accessible via ArcGIS Pro to explore the spatial dynamics of UA within Portland and assess its connection to DEIJ efforts within the city. While this provides a large amount of crucial data, it is essential to acknowledge that there are certain limitations that hinder this research approach. For example, the reliability of the open data provided by ArcGIS Pro provides limited information on the creators of the data charts and maps due to privacy restrictions. As a result, the dependability of the author cannot be determined. Furthermore, this study is centralized around Portland, which could limit the generalizability to other urban environments or cities. This study also inspects varying attributes contributing to DEIJ efforts; however, it is nearly impossible to analyze the UA plot locations against all the varying socio-economic and environmental factors that could play a role in promoting DEIJ. This will be further elaborated on after the literature review. Based on this, while the study offers insights into the spatial dimensions of UA plot placement, it may not perfectly reflect the multilayered socio-economic, environmental, and cultural factors shaping UA dynamics and DEIJ outcomes.

Multidisciplinary Approach

An interdisciplinary approach was necessary to construct this thesis and analyze the interrelated social and environmental features of UA. For instance, the Environmental Science department has a fundamental importance to tackling the scientific intricacies of UA while the Architecture and Landscape Architecture departments are imperative to grasp the impact of UA on urban sustainability based on spatial location. To foster this communication between departments, a partnership with the Agriculture in the Built Environment (AgBE) project led by Dr. Gwynne Mhuireach was formed to create a more holistic study of UA's role and progress in shaping sustainable and equitable urban environments.

Chapter 2: Literature Review

To provide a thorough investigation into UA, this literary review relies on Google Scholar and is centralized around seven keywords: “urban agriculture,” “DEIJ,” “trends,” “global implications,” “social,” “economic,” and “environmental.” Investigating 105 articles and papers published by Google Scholar, the primary findings and knowledge surrounding UA are categorized and summarized within the Literature Review Section. This includes its recent surge in popularity, current global research trends, and connection to the three pillars of sustainability. This literature review also examines gaps of knowledge involving UA in terms of DEIJ as well as investigate the reasons behind choosing Portland as the case study. This includes its current reputation as being a sustainable city as well as its complicated history of discrimination. Through a comprehensive examination of UA literature and case studies, this review aims to contribute to a deeper understanding of the potential of UA as a catalyst for positive change in urban environments.

Relevance

Recent Surge

UA has emerged as a key area of focus in agricultural research, especially concerning innovative and transformative solutions. Dating back to the inception of cities, the practice of UA has become progressively modernized. As such, it has undergone a transformative resurgence amid the current era of rapid urbanization (Philpott, 2010). This has been in response to the increasing urban population, particularly in swiftly developing cities, exerting considerable pressure on both food supplies and urban environments (Specht et al., 2014). As a result, UA has been positioned as a necessary form of agricultural development and has been recognized for its potential to contribute to resilient and sustainable cities (Nogeire-McRae et al., 2018; Pulighe and Lupia, 2020). For example, the significance of UA and its capacity to enhance local food production was showcased in response to the challenges exacerbated by the COVID-19 pandemic (Pulighe and Lupia, 2020). The pandemic, which significantly reshaped the global food security landscape since 2019, has prompted discussions on the necessity of transitioning from extensive food supply chains to shorter, more localized channels. In short, this recent surge underscores the renewed significance of UA as a dynamic and adaptable solution to contemporary challenges and marks it as a key player in the pursuit of sustainable and resilient urban food systems (Yoshida and Yagi, 2021).

Global Trends in Urban Agriculture Research

As evidenced by myriad studies employing bibliometric analysis and visualization mapping, the surge in UA observed in real-world practices is equally mirrored in scientific research. Numerous researchers, drawing insights from the core collection database, have undertaken assessments of the knowledge surrounding UA. Serving as invaluable tools, these analyses identify primary findings that are useful for this research. This can be used to understand the global relevance and track the developmental trajectory of UA research (Langemeyer et al., 2021; Yan et al., 2022). For instance, one study reveals the year-over-year increase in the number of publications related to UA. As shown in Figure 1, there has been an exponential increase from 2000 to 2021 of the number of papers published on UA. This figure, received from the study conducted by Yan in 2022, reveals that out of the 605 total publications, less than 10 were written between 2001-2008 (slow development), 20-40 were written annually between 2009-2014 (steady development), and the rest were written between 2015-2021 with 79 produced in 2020 and 23 published in the first quarter of 2021 (rapid development). Thus, this shows the clear chronological trend in publications on UA with more than 90% being published after 2015; this is indicative of a growing and sustained interest in the field. In short, this surge underscores the increasing recognition of the importance of UA as a focal point in academic discourse and research.

Numbers of Papers on UA Globally Published Over the Years

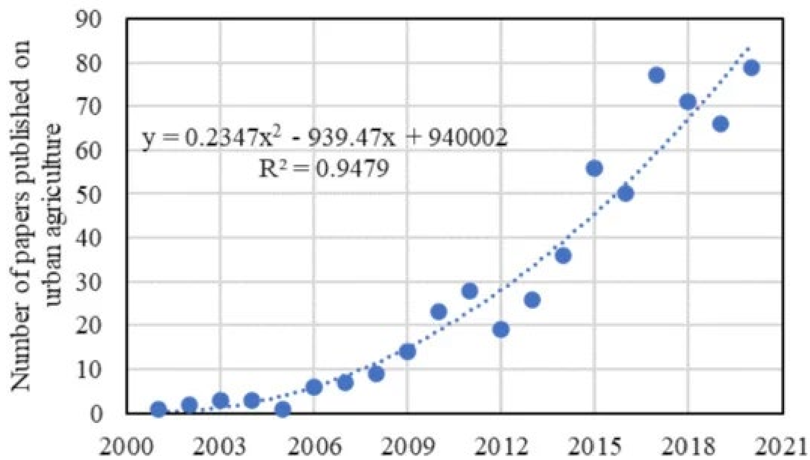

Figure 1. Annual number of papers and articles published on UA from 2000-2021. This figure was obtained from research conducted by Yan et al. that was published in 2022.

Furthermore, this study identifies that within the sixty-four countries that published papers on UA between 2001 and 2021, there are an evident top five that stand out as the most influential countries in UA research: the United States, Germany, the United Kingdom, Italy, and China (Yan et al., 2022). These countries each play fundamental roles in shaping the direction and course of global research. As showcased by Table 1, the United States has a substantial lead on the other countries (Yan et al., 2022). Furthermore, there is a collaborative nature of these international efforts to advance UA research. Among these five countries, the United States appears as a prominent center in the linkages between countries (Zhang et al. 2020). In summary, the findings of this study accentuate the recent rise of literature on UA as well as the significant influence the United States, Germany, the United Kingdom, Italy, and China have in shaping global UA research.

Top 10 Nations Contributing to UA Literary Research

Countries	Number of Papers	Frequency	SCP	MCP	Total Number of Citations	Average Citations for Each Paper
USA	132	22.0	116	16	2372	18.0
Germany	40	6.7	17	23	812	20.3
UK	34	5.7	21	13	611	18.0
Italy	31	5.1	21	10	825	26.6
China	30	5.0	19	11	293	9.8
Canada	27	4.5	21	6	608	22.5
France	27	4.5	17	10	439	16.2
Brazil	25	4.2	17	8	68	2.7
South Africa	25	4.2	19	6	202	8.1
Australia	24	4.1	19	5	500	20.8

Table 1: The top 10 nations with the most extensive research output on UA based on the number of published papers, the frequency, the single country publication (SCP), the multiple country publication (MCP), the total number of citations, and the average number of citations per paper. This table was obtained from research conducted by Yan et al. that was published in 2022.

Potential of UA

While UA is unlikely to render cities entirely sufficient in terms of food self-reliance, myriad studies reflect UA's potential to aid in food security. This is particularly achieved on smaller scales such as specific city districts or households and for certain food items. These studies highlight the significant role of UA in improving food security for low-income households and boosting cities' autonomy in certain food commodities. The importance of UA has been reflected across the globe by countries experiencing drastically different situations and environments. For example, the reliance of densely populated areas like Greater Accra on locally grown vegetables, with domestic production meeting 90 percent of the region's vegetable consumption, reflects the hidden potential within UA if it is utilized productively (Maxwell and Armar-Klemesu, 1998). Furthermore, highly urbanized island states such as Fiji and city-states like Hong Kong exemplify the ability of UA to achieve elevated levels of food self-reliance (Mougeot, 2000). Finally, without the aid of UA efforts, studies reveal that cities such as Lome and Kampala would experience even greater food shortages (Kouvonou et al., 1998; Maxwell, 1995). In addition to relieving food insecurity, UA also plays an essential role in nurturing synergistic connections between urban and rural communities. For example, research conducted in Dar es Salaam and India reveals a reciprocal exchange of knowledge, resources, and goods between urban and rural areas. This underscores the necessity for reliant documentation and communication to devise sustainable local food systems (Stevenson et al., 1996; Panigrahi, 1995). In essence, UA serves as a vital complement to rural agriculture, contributing to food security, fostering urban food self-reliance, and building connections between urban and rural communities.

Sustainability of UA

The topic of sustainability is a simple term to comprehend yet complex concept to achieve. For something to be considered sustainable, it needs to last and adapt to a constantly changing environment. When considering the sustainability of UA and the food system, there are three primary pillars that should be addressed: social, economic, and environmental. Often referred to as a balancing act among these three factors, it has been shown repeatedly that failure by any of these pillars of sustainability will result in the system crumbling (Hansmann et al., 2012).

Agriculturists have found themselves at the forefront of trying to establish an equilibrium among the pillars that respects both short- and long-term social, economic, and environmental needs (Wolf, 2018). As a result, two contending philosophies have emerged (Garnett et al. 2014).. The first philosophy prioritizes efficiency and productivity to sustain and provide enough food to the growing population (Garnett et al. 2014). Conversely, the other philosophy is focused more heavily on the environmental concerns of this rising population including concerns regarding water, soil, and the availability and health of other natural resources (Garnett et al. 2014). While there is overlap behind their goals and both philosophies recognize the significance behind the opposing side's argument, these two philosophies reflect the constant tension involved with the three pillars of sustainability (Garnett et al. 2014).

This tension is also experienced on a more personal level with farmers and growers struggling to balance the short-term economic challenges with the long-term environmental concerns. These issues are conspicuous in urban settings where pressures are compounded by population density, land scarcity, and competing land-use demands (Fletcher et al., 2020). Due to this rationale, agriculture, namely grain crops and animal production, are seldom the most rational options. Instead, UA tends to prioritize space-efficient horticulture crops that yield high profits. In short, there are countless considerations that must be made in terms of UA to ensure a healthy balance within the three pillars of sustainability.

Advantages of UA within the Three Pillars of Sustainability

To fully understand the complexities of UA through the lens of DEIJ, it is necessary to view its interconnected relationship with the three pillars of sustainability. For this thesis, diversity and inclusion are seen as a social construct, equity is seen as an economic concept and justice is viewed through an environmental lens.

Social

When built on derelict land in economically disadvantaged suburbs and cities, UA can contribute heavily to social sustainability in numerous ways: nurturing community cohesion, promoting food justice, and catalyzing grassroots activism (Alaimo et al., 2010; Glover, 2004).

In particularly underprivileged regions where access to fresh food is restricted, UA serves to develop a shared social and cultural identity among urban residents by offering a platform for community empowerment and direct participation with food production and procurement (van Averbeke, 2007; Mees and Stone, 2012; de Zeeuw et al., 1999). For example, the results of a study conducted in the San Francisco Bay Area of California, which surveyed 450 direct market shoppers and 424 gardeners, found that social connection was one of the leading reasons for UA engagement (Diekmann et al., 2020). This lends credence to the widely held belief that community gardens can be used as venues for promoting socializing, cooperation, and mutual support (Diekmann et al., 2020).

Furthermore, it has been demonstrated that some localized food systems stimulate political involvement and engagement. Historically, community gardens have functioned as hubs for grassroots political opposition (Ernwein, 2014; Schmelzkopf, 1995). By encouraging the growth of social and political competencies that enable involvement in advancing food democracy and more general democratic processes, this type of community gardening participation can allow people to become more actively involved in their communities (Saldivar-Tanaka and Krasny, 2004, Wakefield et al., 2007; Barron, 2017). To summarize, the examination of the societal advantages that arise from UA reflects the critical role that UA plays in developing community cohesiveness, food justice, and grassroots activism, which are critical to the development of social involvement in urban contexts.

Economic

The economic sustainability provided by UA has also been extensively investigated, with a notable emphasis on various facets such as food security and economic stability (Armanda et al., 2019). Across historical contexts and contemporary settings, these factors have consistently emerged as primary drivers that motivate participation in UA (Ackerman et al., 2014). Providing roughly 10% of the global food supply, UA has a massive economic impact that has the potential to augment household income, reduce food expenses, and generate employment opportunities (Ackerman et al., 2014; Graefe et al., 2008). The degree to which UA supplements household income varies significantly and is influenced by factors such as the geographic location, choice of crops, and the scale of production. For instance, in the majority of cases, staple crops like rice have been shown to provide a reliable source of income for households while vegetables often command higher market prices (Graefe et al., 2008; Martellozzo et al., 2014; Vagneron, 2007). In certain instances, UA serves as the sole reported source of income for households and can play a significant role in poverty alleviation efforts in less advantaged countries (Graefe et al., 2008; Van Averbeke, 2007). Overall, the economic benefits of UA underscore its pivotal role in promoting household income stability, poverty alleviation, and overall economic resilience within urban communities.

Environmental

The final pillar of sustainability that is upheld by UA is environmental. Urban farms and community food gardens can serve as a type of green infrastructure that can ameliorate the effects of urban stormwater, reduce the energy required for food transportation, and lessen the effects of urban heat islands.

Creating agricultural space for stormwater management, UA has numerous benefits that have been shown to effectively manage stormwater runoff levels and improve runoff quality. For instance, the process of urban growth has led to the creation of impermeable surfaces, which reduce the ability of water to seep into the ground and increase the amount of water that flows over the surface during storms (Feng et al., 2021; Marçal et al., 2021; McGlinchy et al., 2019).

However, this issue can be alleviated through the introduction of UA throughout the city since utilizing plants and soils can effectively control water and provide more sustainable urban settings (Ebissa and Desta, 2022). This ideology is supported by the Environmental Protection Agency (EPA) of America, which states that risks caused from extensive rainwater qualities can be effectively addressed through the implementation of UA (Ebissa and Desta, 2022). This can serve multiple purposes, such as flood protection, habitat creation, purified water, and cleaner air (Ebissa and Desta, 2022). This is clearly illustrated through the ability of green roofs to retain between 52.3 and 100 percent of precipitation and limit the concentration of heavy metals in runoff compared to the typical non-vegetated roofs (Berndtsson et al., 2006; Berndtsson, 2010; Emilsson et al., 2007; Getter et al., 2007; Hathaway et al., 2008; Rowe, 2011; VanWoert et al., 2005). This has attracted significant attention in municipal policy in places like Portland, Oregon (Liptan, 2005). In short, incorporating UA into cities has numerous stormwater management advantages that contribute to more sustainable urban environments.

Additionally, by decreasing the distance that food needs to travel from the farm to the table, UA can reduce the amount of energy used in food transportation. According to estimates, the average distance that food travels is around 1,300 miles (2,080 km) (Peters et al., 2009). However, for certain items, this distance could be decreased to thirty miles (49 km) if they were produced in closer proximity to the consumer (Peters et al., 2009). Initial research indicates that minimizing the distance that food travels can have a pivotal impact in preventing spoiling and subsequent food waste (Ackerman et al., 2012). Moreover, local recycling and re-use of organic waste facilitated by UA could enhance nutrient cycling, which could consequently diminish the ecological footprint of urban centers (Peters et al., 2009; de Zeeuw et al., 1999). This concept is practiced by a considerable number of rooftop farms that depend on compost derived from locally gathered food scraps (Peters et al., 2009; de Zeeuw et al., 1999). Overall, UA has the potential to support environmental sustainability by lowering the energy consumption associated with food transportation.

Furthermore, increasing the amount of vegetation in urban areas has become a common method to mitigate the Urban Heat Island (UHI) effect, which is defined as the urban zone's temperature being higher than the surrounding rural areas (Eom et al., 2012). The range of this temperature disparity is 0.6˚C to 12˚C (Campbell, 2017). Vegetation plays a crucial role in changing the heat dynamics of cities (Alexandri and Jones, 2008). This is achieved through the diffusion of light reflected from surrounding surfaces and the absorption and dispersion of incoming solar radiation that help reduce the amount of heat that urban surfaces absorb and reradiate (Qui et al., 2013). Furthermore, compared to non-vegetated metropolitan areas, the evapotranspiration process in vegetated regions functions as a heat sink, resulting in lower ambient and surface temperatures. Thus, due to the lack of ground-level space for green areas in urban environments, rooftop gardens have emerged as a favored design that can result in a massive cooling effect. In short, UA can help mitigate the implications surrounding UHI and contribute to environmental sustainability.

Disadvantages of UA within the Three Pillars of Sustainability

However, despite the social, economic and environmental benefits of UA, there are also evident drawbacks to UA that have been reflected in a more critical body of literature. This literature analyzes the relations between UA in a less positive light and stresses the need for further investigation on UA and its impacts.

Social

Although numerous studies show that UA has the potential to alleviate issues of discrimination and oppression, there is contrasting research that warns UA could further inequality, gentrification, and systemic barriers (Goodlings et al., 2015). This research asserts that, without specific actions to address racial disparity, UA could perpetuate social inequality due to disproportionate access of resources in marginalized communities (Billings, 2018; Goodlings et al., 2015). Furthermore, some studies have found a clear correlation between UA, namely at the residential level, and the continuous process of gentrification in the city (Hern, 2016; McClintock et al. 2016; McClintock et al 2020; Shinew et al., 2004). Representing the constant tension between privilege and oppression, gentrification in cities typically involves the arrival of affluent white people and the displacement of individuals with low incomes and people of color (Billings, 2018). As a result of historical oppression and ongoing displacement in cities experiencing gentrification, UA also encounters problems with systemic barriers including a lack of land access, time, or money. From a societal standpoint, this could undermine UA efforts to achieve true social justice and equity.

Economic

Whether commercial, non-commercial, or community-based, UA also has economic downsides including being costly, labor-intensive, and challenging to establish and sustain (Dimitri et al., 2016). For instance, one study that interviews 17 black community gardeners and evaluates UA in Portland from an economic standpoint asserts that despite the abundance and widespread distribution of UA in Portland, there are still waitlists for applicants and the prices of plots can vary from $15 for a 50 sq. foot plot to roughly $200 for an 800 sq. foot plot (Billings, 2018). On top of that, there is the additional cost of material and resources. As a result, many black families that are struggling financially could find it too expensive to maintain a garden plot given the additional expenses involved (Billings, 2018). One interviewee touches on this problem and states:

> “But our dilemma is most of the time we’re in crisis and we’re just worried about the next day. We’re not looking to think about future, weeks down the line, because that’s just not where we’re at right now. We’re looking to survive right now, like ‘I need a place right now,’ or ‘I need food right now.’ I am not talking about spending 100 dollars to grow some stuff and I may not have time”’ (qtd. Billings, 2018).

This quote highlights that, although UA has the potential to deter existing inequalities, there are also hidden complexities that could cause UA to exacerbate economic disparities in minoritized communities and heighten the challenges they face in achieving economic sustainability.

Environmental

Finally, there are a plethora of environmental concerns in response to the sustainability of UA: contaminated soil, pesticides and fertilizer runoff, and water usage. Due to the air deposition, industrial pollutants, transportation, and the dumping of municipal solid waste in urban areas, contaminated soil is a major concern for UA (Wei et al., 2010; Wu et al., 2015; Ferreira et al., 2016). Recent research found that certain harmful substances, such as heavy metals, bioaccumulate in food and vegetables grown in UA (Cruz et al., 2014; Dias-Ferreira et al., 2016). These contaminants can build up in plants in copious quantities and spread to animals and humans through consumption, which can pose a massive health risk (Nabuloa et al., 2006; Rodrigues et al., 2013; Singh et al., 2012). Another environmental downside of UA is the use and runoff of pesticides and fertilizer. While the use of pesticides has become important for managing infestations of diseases and pests and the application of fertilizers and nutrients can enhance plant development, studies warn that there are myriad issues that stem from pesticide and nutrient leaching in runoff (McIntyre and Snodgrass, 2010). This includes increased pollution, eutrophication, and health concerns (Moseley et al., 2008; Wortman and Lovell, 2013). This is furthered if water runoff collection and reuse methods are not employed (Getter and Rowe, 2009). Another environmental concern in UA is water usage. Agriculture, which accounts for 87% of the freshwater utilized in the United States, has been under increased scrutiny for its water management methods (Pimentel et al., 1997). Since most UA in the United States only have access to water that is treated to accommodate drinking standards, a unique concern emerges. With approximately 40 to 70 percent of the water consumed by households being dedicated to the irrigation of UA and lawns, there can be an added stress on water demand in cities (Hilaire et al., 2008). This is intensified as concerns around climate variability and the urban heat island effect grow (Wortman and Lovell, 2013). In short, there are numerous environmental concerns surrounding the concept of UA.

Gaps in Existing Knowledge

Despite the recent surge of publications that focus on the rise and significance of UA, there is still a discernible knowledge gap that exists. This is evidenced in Yan's 2022 study, highlighting keyword co-occurrence patterns in the literature, contributing to the advancement of UA understanding. Simply put, keyword co-occurrence is the presence of the same keyword in two or more articles that reflect the popular research topics in the discipline and can be used to support scientific investigations with more data (Liao et al., 2018). As shown in Figure 2, fifty keywords underwent analysis in R, and they were grouped into eight clusters based on their co-occurrence frequency (Yan et al., 2022). These clusters were visually represented using distinct colors. The connections between nodes within the clusters reflected the frequency of their co-occurrence, offering a quantitative measure to illustrate their interrelationships.

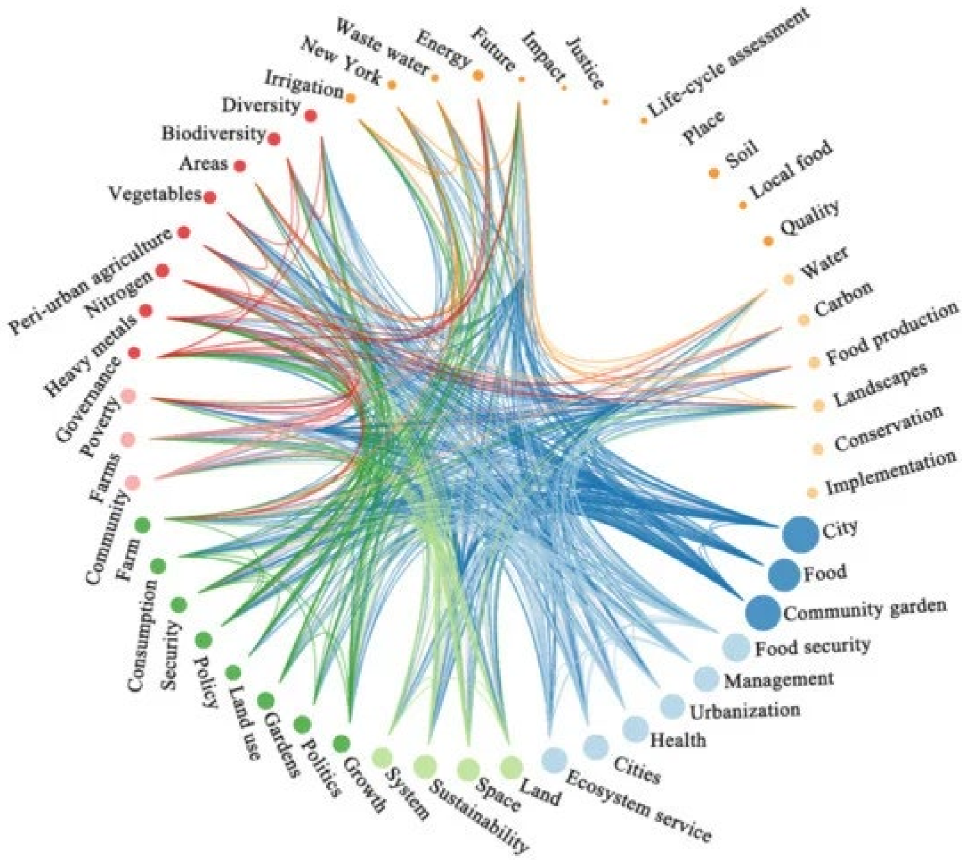

Fig 2. Examining the correlation and co-occurrence of keywords in UA literature spanning from 2001 to 2021. This was obtained from research conducted by Yan et al. that was published in 2022.

Based on the clustering and frequent associations with other keywords, Figure 2 suggests a predominant focus of UA research on urban food production and green spaces as shown by the consistent use "food," "city," and "community garden." Particularly, "community garden" are shown to be the most recurrent type of UA and have significantly contributed to enhancing urban resilience by bolstering food security and public health. Another cluster of keywords encompasses "urbanization," "food security," "management," "health," and "cities," and indicates an imminent demand for UA research to shed light on its economic, environmental, and social dimensions to create healthier urban lifestyles. Utilizing this depiction, it became feasible to pinpoint research avenues that offer valuable insights while addressing knowledge gaps. For instance, while there is a clear focus on the relationship between UA and urbanization, there are no prominent links between "justice" and "impact." As a result, there is an evident need to connect DEIJ efforts to the impacts of UA in an urbanized environment.

DEIJ Definition

In order to address and uphold human rights, DEIJ recognizes that oppressive systems are embedded within global social, economic, and environmental systems; it approaches work and its internal and external processes with the understanding that society is fundamentally unequal. However, this is another gap of knowledge that needs to be addressed when analyzing UA. The acronym DEIJ has been used so frequently to the point that its meaning is often misunderstood, and the terms are grouped together with a single interpretation. Thus, it is important to recognize that DEIJ is composed of four different words: diversity, equity, inclusion, and justice. In order to understand this acronym, one must have a clear definition for each of the words and comprehend the overlap and differences between them (Glenn and Elswick 2020; Potter and Hylton, 2022).

For this thesis, diversity refers to the presence and representation of a group of individuals who are, simply stated, diverse. It is the equal and representational presence of people with intersecting identities rather than just the presence of "minoritized" individuals. This covers a wide range of characteristics, including but not limited to, race and ethnicity, age, languages spoken, national origin, sexual orientation, gender and gender identity, physical ability, and political affiliation. Being a relational concept, it should be used to describe a collective whole rather than a single individual.

Equity, which is sometimes mistaken for equality, is the process of putting in place procedures that are just and equitable across every group of individuals. Simply put, individualistic needs are prioritized when we treat people equitably, as opposed to treating everyone the same when we treat them equally. Recognizing that every person has unique needs, experiences, and opportunities is a requirement of equity. Adhering to the premise of equity involves establishing settings in which any person or group may feel appreciated, supported, accepted, and able to engage completely. For example, when it comes to obtaining resources and opportunities, disadvantaged groups frequently face more obstacles than more privileged groups. Equity-inspired design finds obstacles and injustices in a diverse setting and helps level the playing field for those who are marginalized.

Inclusion refers to when all groups are acknowledged, given advantageous access to resources such as programs and systems, and are not discouraged based on personal traits. Unfortunately, since it is related to the quality of human experience, inclusion does not just occur; but rather, people must design for it. For instance, because inclusion is not a logical byproduct of having a varied team or organization, there is a possibility that a group of people might have diversity without also being inclusive.

Finally, although there is an array of viewpoints on the notion of justice, this thesis addresses it through the lens of environmental justice (EJ). The idea that a healthy environment is a fundamental right for all living things on Earth is reaffirmed by the 1992 Rio Declaration (UN). Despite this, disparities in the distribution of environmental hazards persist across societies, impacting specific groups disproportionately. As articulated by Cutter (1995),

> "The principle of environmental justice guarantees 1) the protection from environmental degradation; 2) prevention of adverse health impacts from deteriorating environmental conditions before the harm occurs, not afterwards; 3) mechanisms for assigning culpability and shifting the burden of proof of contamination to polluters not residents; and 4) redressing the impacts with targeted remedial action and resources."

Underscoring the importance of recognizing and mitigating disparities in environmental hazard exposure, EJ provides a vital perspective for analyzing UA that can help ensure fair access to resources as well as limit environmental injustices. By encouraging people to consider the differential impacts that environmental hazards have on marginalized communities, a focus on UA through the premise of EJ allows for additional clarity on the current and future initiatives that are aimed at improving food security and sustainability. Thus, by embracing the principles of EJ, UA practices can contribute to building more resilient urban environments.

Limitations to DEIJ Perspective

Perhaps the largest limitation is the scope of this study. As highlighted by the definitions of the four components of DEIJ, there are numerous possibilities and methods that can be used to measure UA through the lens of DEIJ. For example, for diversity alone, it can be observed through numerous attributes including but not limited to race and ethnicity, age, languages spoken, national origin, sexual orientation, gender and gender identity, physical ability, and political affiliation. However, this study focuses on one characteristic for each of the four components. For this study, diversity is observed through racial demographics, equity is highlighted through an economic standpoint, inclusion is shown through accessibility, and justice is centralized on the environment.

Portland – Case Study

While UA at first glance appears to be a necessary and simple solution to rising levels of urbanization within literature, there are problematic complexities within UA that arise in response to the stresses in the real-world. To understand this, Portland, Oregon was chosen as the case study to analyze DEIJ efforts within UA for numerous reasons: its reputation, history, and DEIJ efforts.

From a sustainability perspective, Portland, Oregon upholds a good reputation and is widely recognized as a frontrunner in the United States in the race to create a sustainable urban setting through UA. According to Renner (2016), Portland is one of the "top ten cities in the United States for urban farming." Focusing solely on Portland's commitment to sustainability through agriculture, the idyllic perception on UA and its plentiful benefits is furthered.

However, as stated, the stresses of the world can induce unforeseen downsides and consequences in UA. As such, Portland was not chosen exclusively on its reputation as a green and sustainable city, but also based on its complicated history with DEIJ efforts resulting from discrimination and its ongoing battles against gentrification. As reflected in the 1844 laws that excluded black people from residing in Oregon, the state of Oregon and the city of Portland both have a long-standing history of racism (Bates et al. 2014). While the passage and ratification of the 14th amendment in Oregon in 1866 resulted in minor modifications to these regulations, Oregon revoked its ratification of the amendment in 1868 and did not fully ratify it until 1973, more than a century later (Billings, 2018; Hern, 2016). It was not until 1926 that the provision prohibiting black people from entering and residing in Oregon was formally repealed (Gibson, 2007). However, that was not the end of Portland's encounters with discrimination. In response to 1,100 black residents that moved into Oregon after the lifting of the provisions, the nationwide KKK revival furthered issues of discrimination, and was welcomed in cities such as Portland by more than 35,000 card carrying members (Burke and Jeffries, 2016). Fortunately, in Northeast Portland and the surrounding districts, black residents persevered to establish a community (Billings, 2018). However, although these biases may have merely changed over time into more subdued forms, overt forms of racism and discrimination still exists with ramifications on minoritized groups. For instance, research throughout the years suggests that discriminatory practices used to control Portland's boundaries, including redlining, abuse of power, de facto segregation, and physical violence, continue to perpetuate DEIJ issues and further racial disparity within the city (Billings, 2018, Gibson, 2007; Hern, 2016). As a result, the clash between the positive reputation of sustainability and the dark history of discrimination in Portland makes it an ideal case study for understanding the impacts that UA has on both sustainability and DEIJ efforts.

Chapter 3: Methodology

Methods:

Overview

This thesis relies on a multifaceted approach that integrates a literature review, spatial mapping analysis, and quantitative data graphs and charts. Separating DEIJ into its four components (diversity, equity, inclusion, and justice), this thesis was able to analyze DEIJ within UA through multiple perspectives. From a societal standpoint, the location and diversity of UA plots were assessed based on Portland's racial and ethnic demographics. The equity of UA was determined through a spatial analysis of the median household income in relation to plot location to provide an economical perspective. From an accessibility standpoint, inclusion of UA within Portland was acknowledged. Finally, UA's connection to justice exposes an environmental reflection. By investigating the data in this format, this thesis is able to analyze UA's interconnected relationship with both the three pillars of sustainability and the 4 separate components of DEIJ.

Basemap Creation

To create the base map for this study, ArcGIS software was utilized. The first step was collecting essential geographical data layers. The city boundaries were obtained from the GIS-PDX open data. This shapefile provided the foundational framework for delineating the outline boundary of Portland, Oregon. Additionally, neighborhood boundaries were also gathered from the GIS-PDX open data source. This shapefile defined the various neighborhoods within the city. Unlike the city boundaries which were given a black line color, the interior of the neighborhoods was highlighted in green for clarity against the backdrop.

The precise locations of UA plots and their level of quality and accessibility were then identified through a process involving data extraction from the official Portland government website as well as a review of local websites on UA organizations; this was later verified through Google Earth searches that provided the exact coordinates of the UA as well as the size of the plots. This data was kept in an Excel spreadsheet for further analysis. To measure diversity, equity, and inclusion, this data was limited to community gardens, community farms, and rooftop gardens since they are the most accessible to the community. However, to measure the justice aspect, eco-roofs were included. Eco-roofs, also referred to as green roofs, are vegetated roof systems that have been shown to have a substantial impact on the environment (Teotónio et al., 2018). To align with this, the basemap only includes community gardens, community farms, and rooftop gardens.

These layers were combined using the spatial tool in ArcGIS to produce a simple and easy-to-read basemap that would provide a blueprint for further DEIJ research. In order to create a visual representation of the geographical context, the neighborhood delineations and plot locations were overlaid and enclosed inside the city limits. Throughout the study, this basemap is an essential point of reference that makes it easier to analyze how UA plots are distributed spatially in Portland.

Diversity - Race and Ethnicity Data

Dot Density Map

Using the open data repository in ArcGIS software and the Census 2020 data, a diversity map was produced to reflect the distribution of racial and ethnic groups in Oregon. The choice of dot density mapping was deemed optimal for conveying the intricate variations in population composition across different geographic areas. This is because it provided comprehensive insights into the population demographics at various spatial scales, including county, tract, block, and building footprints. The dot density mapping technique was used to visually represent the population distribution by race and ethnicity across Oregon. Each dot on the map symbolizes multiple individuals to depict population density and spatial patterns.

The specific focus of this analysis was on tract-level data, because it can offer a fine-grained resolution for examining demographic trends within distinct geographical subdivisions as well as localized variations in racial and ethnic distribution. When analyzing using ArcGIS pro, this allowed for a more informative overview of the data due to its interactive nature. To enhance interpretability, the inclusion of additional features (provided by the open data repository) such as State Redistricting Committee Proposals, Congressional Districts (CD), State Legislative Districts (SLDs), and American Indian, Alaska Native, and Native Hawaiian Areas (AIANNH) were omitted. This decision was made to maintain simplicity and focus solely on the racial and ethnic composition of Oregon's population at the tract level.

The color scheme used in the map adhered to Arthur & Passini's principle of choosing contrast colors for effective visualization. Yellow was specifically designated to represent the "White, not Hispanic or Latino" population due to its high visibility and compatibility with various background colors. This deliberate color choice facilitated clear differentiation and interpretation of racial and ethnic distributions on the map. In short, the methodology involved leveraging Census 2020 data, employing dot density mapping at the tract level, and utilizing a carefully selected color scheme to create a visually informative diversity map focusing on racial and ethnic demographics within Oregon.

This map was then overlayed with the basemap to constrict the data to the boundaries of Portland, Oregon. The neighborhood boundaries were changed to a solid dark blue color to both stand against the dark background as well as highlight the dot colors. Furthermore, the UA plots were adjusted to a white color with a black outline so they would not get confused with the racial dot density data.

Racial Demographic Clustered Bar Graph

Using relevant data from the United States Census Bureau, a clustered bar graph was designed to compare the racial demographics in the United States with the racial demographics in Portland, Oregon.

Race and Ethnicity Map

Data for the race and ethnicity map were obtained from the ArcGIS open data repository. The map was generated using information sourced from the US Census American Community Survey 5-year estimates and covers the period from 2014 to 2018. The dataset relies on a map published by the Public Bureau of Transportation (PBOT) that was created and updated in June 2021, and August 2021, respectively. This data from PBOT provides population data categorized by race and ethnicity for different census tracts.

The race and ethnicity score were computed based on the percentage of people of color or Latinx (of any race) within each census tract. This calculation was performed using the Natural Breaks method, which divides the data into distinct categories. Each census tract was assigned a score ranging from 1 to 5. The scoring system categorizes tracts based on their racial and ethnic diversity, with lower scores indicating a higher proportion of white residents and higher scores indicating greater racial and ethnic diversity. In other words, a higher score reflects a greater percentage of citizens who self-identified as persons of color or Latinx (of any race) in the U.S. Census. In this case, 1 represents the lowest degree of diversity (0–20%) and 5 represents the highest level of diversity (80–100%) on this map, and this score shows the relationship between racial differences and UA plot sites. The calculated race and ethnicity scores were integrated into the map, providing a visual representation of the racial and ethnic composition across different areas within the study area. The combined scores were utilized to assess the level of diversity and segregation within the community.

After the race and ethnicity score were determined, this data was joined to the basemap through the spatial join action in ArcGIS pro. The boundary colors were changed to white to contrast the blue color scale used to reflect the race and ethnicity scale. Additionally, the UA plots were kept an orange color to make them standout against the dark map colors.

Race and Ethnicity Bar Graph

Using the Race and Ethnicity score generated by the map, a bar graph was then created in ArcGIS to analyze the plot locations in relation to the race and ethnicity score of Portland neighborhoods. The color of this bar graph was made to match the color spectrum of the map.

Equity - Median Household Income Data

Median Household Income Map

The next map that was created reflects the median household income and its relation to UA plot location. To create this, a map of the average household income that was provided in the open database for ArcGIS was utilized. The dataset that was used to create this map relied on the most current release of 5-year estimates by tract in Portland provided by the Census Bureau's API for the American Community Survey and was generated in May 2023 and updated in June 2023. The feature layer reflects the median household income levels within each tract boundary. However, to limit the scope of the data, it was decided to exclude the state and county census data, extract the median household income data using the Overlay Layers analysis tool, and use the Metro RLIS to create the city boundary polygon. The boundaries used in the dataset are from the US Census TIGER geodatabases, specifically the National Sub-State Geography Database, with water and coastlines erased for cartographic and mapping purposes.

Using spatial join in ArcGIS pro, this map was then re-combined with the basemap to provide a visual analysis that juxtaposes the income data with data on UA plot locations to explore potential relationships and patterns. To be visually appealing, this map has an orange to grey color scheme with orange reflecting lower average household incomes and grey showcasing higher average household incomes. The UA plots were colored black so they would stand out against the income color scheme.

Median Household Income Histogram

To analyze this plot, a histogram was created in ArcGIS to understand the relationship between income in the area. On the x-axis, 10 bins were created to represent the distribution of median household income in past 12 months (inflation-adjusted dollars to last year of 5-year range) in Portland. On the Y-axis, the number of UA plots that fell into each bin was counted and graphed.

Inclusion – Access to UA Plots Data

Private and Public UA Plots Map

Another component of the investigation entailed generating a map to evaluate inclusivity based on the accessibility of UA plots, distinguishing between public and private ownership. The official website of the Portland government provided information that was used to assess each plot's accessibility. However, additional verification was conducted using Google Earth to evaluate the quality and establish whether the plot was accessible to the public if the ownership status was not made clear on the website. After this procedure, the basic map was overlayed with the acquired data. Plots that were classified as private were indicated by red dots, whereas plots classified as public were represented by green dots. As a result, using a mapping method, the inclusion of UA projects in the study region was visually represented, emphasizing issues of accessibility and potential disparities in access to UA resources.

Private and Public Pie Chart

To understand this map, a pie chart was created in ArcGIS pro to represent the number of plots that were public (green) and the number of plots that were private (red). This provides a simple and clear visual representation of the data.

Justice – Environmental Analysis Data

Environmental Hazard Index and UHI Maps

The final maps that were generated combined a map created by Oregon Metro available on ArcGIS open data repository with the basemap created for this thesis. To analyze the environmental aspects of UA and DEIJ, two maps were created. The first map that was used from ArcGIS reflects the estimated potential hazards and showcases an environmental hazard potential index that takes into account variables including topographic wetness and UHI. The topographic wetness indicates places prone to nuisance flooding and the UHI describes metropolitan or developed areas that have higher temperatures than adjacent rural areas. The total hazard potential is determined by the combined influence of several environmental stressors; higher hazard potential is shown by red while lower hazard potential is shown by deeper blue. This map was joined to the basemap to reflect the UA plots with the hazards. However, since the basemap only includes community gardens, community farms, and rooftop gardens (represented by orange), eco-roofs were also included (represented in green) due to their environmental contribution. To further unravel and understand this map from Oregon Metro, this thesis omitted the wetness Index feature from the Oregon Metro map to analyze the implications of UHI with the plot placement of UA. In a color gradient, this map reflected the deviation from regional average temperature as well as the community gardens, community farms, rooftop gardens, and eco-roofs.

UHI Histogram

To analyze the impact of UA on environmental justice, a histogram was created on ArcGIS Pro. The x-axis represents the urban heat index deviation from the average in 23 bins with a range of -9.2 to 4.1 degrees Fahrenheit. On the other hand, the y-axis shows the number of UA plots that fell into that bin.

Chapter 4: Results

Overview

In this results section, seven maps alongside five plots were produced to analyze the plot location and accessibility and its implications for DEIJ in Portland neighborhoods. Each of the informative plots provides a different outlook on the four aspects of DEIJ – diversity, equity, inclusion, and justice.

Overall, 41% of the neighborhoods contain a form of UA in the basemap. However, based on the size differences of the neighborhoods, this does not accurately represent the spread of UA throughout the city. This map indicates that, while there are signs of clustering in certain neighborhoods such as Cully, with 6 UA plots, and Portsmouth, with 4 UA plots, there is a good distribution of plots between the neighborhoods. Additionally, there are larger gaps between plots in the Northwest regions of Portland due to the limited number of housings in that area compared to other parts of Portland.

Basemap of UA Placement with City and Neighborhood Boundaries in Portland, Oregon

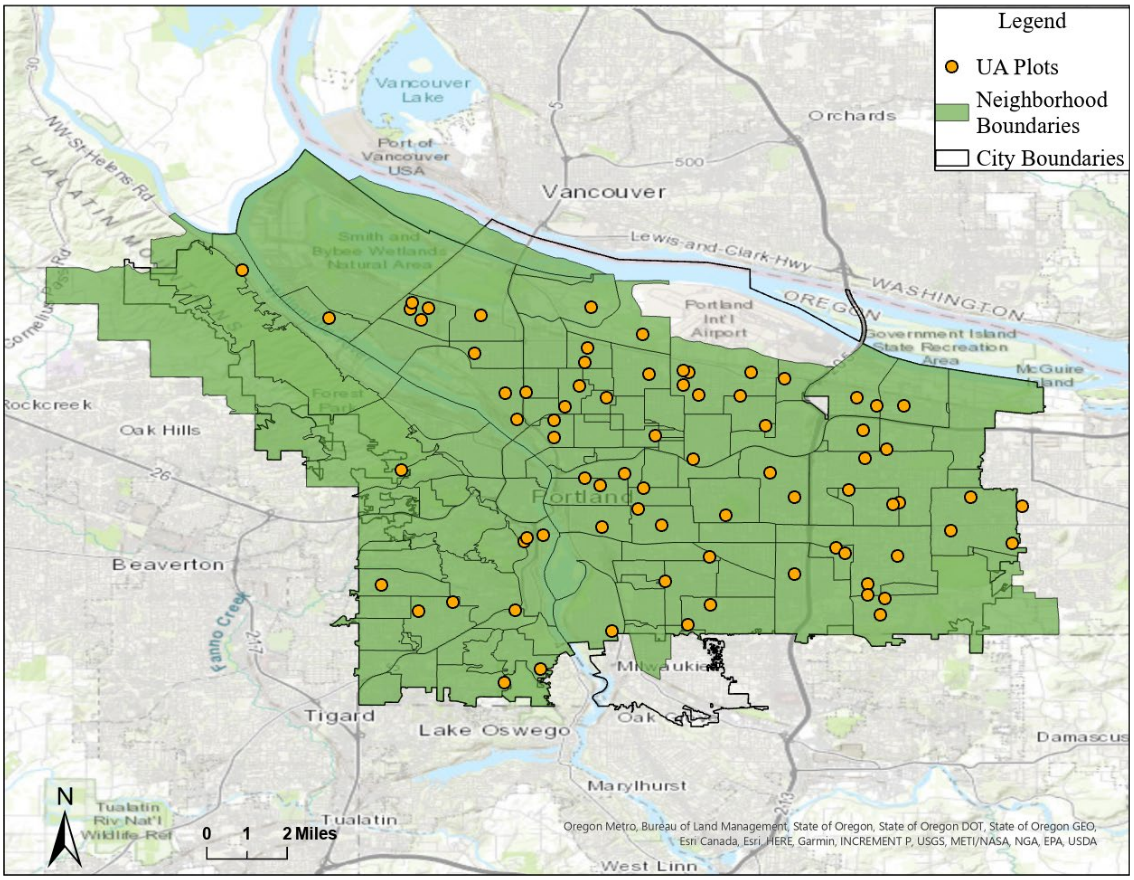

Figure 3: Basemap of the neighborhoods (green), city boundary (black lines), and UA plots (orange) including community gardens, community farms, and rooftop gardens in Portland, Oregon.

Diversity

Dot Density Map

A dot density map was created as a visualization technique to understand the racial demographic in Portland, Oregon (Fig. 4). In addition to showcasing the racial demographic, this map also reflects the distribution of the population in Portland with more people residing in the center of Portland compared to the Northwest quadrants. In this map, one dot represents approximately 16 people in the area. This allows for a granular depiction of population density and racial distribution across the city and is useful for highlighting patterns of residential segregation and diversity within Portland neighborhoods.

Dot Density Map of UA and Racial Demographics in Portland, Oregon

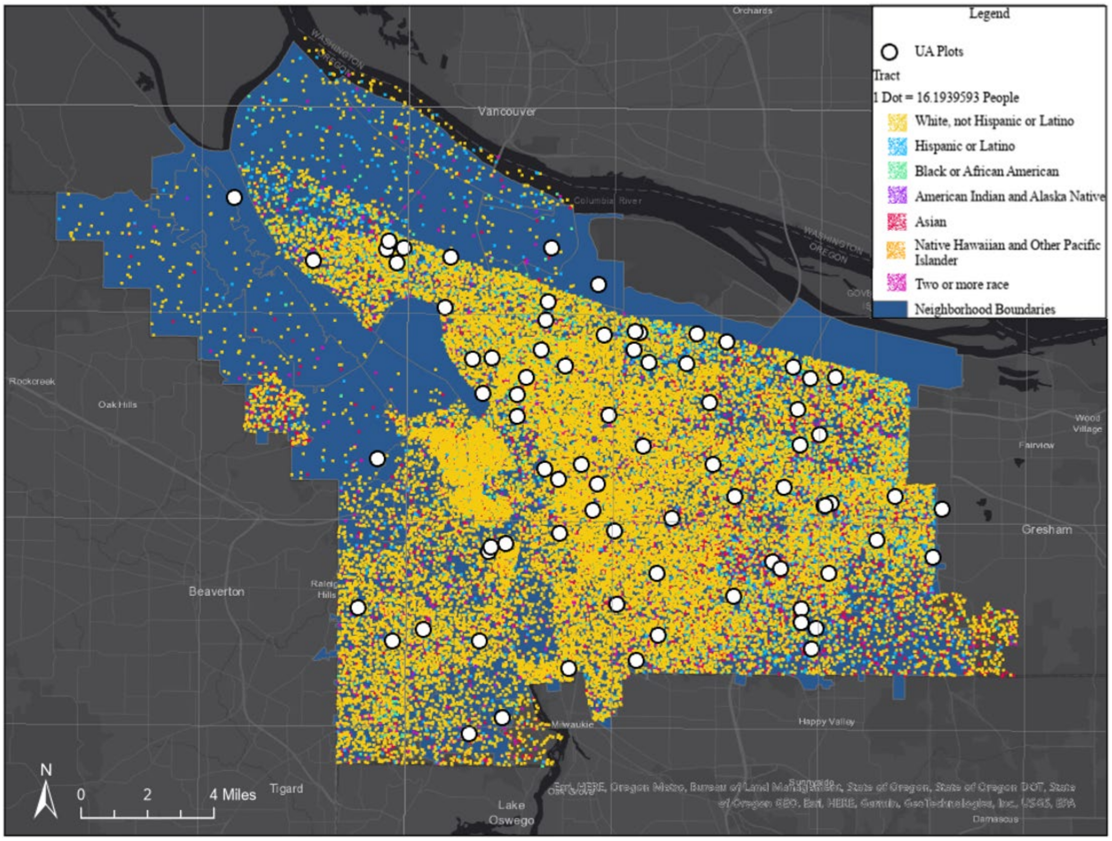

Figure 4: Dot density map that represents the racial demographic within Portland, Oregon. The white dots symbolize UA plots while the colored dots symbolize different racial demographics.

To better understand the racial distribution of the map, data provided by the United States Census Bureau was analyzed to create a clustered bar graph (Fig. 5). This was created to analyze the difference between the racial demographics in the United States and Portland. Based on this bar graph, the United States and Portland reflect common trends with the highest to lowest demographics being White, Hispanic or Latino, Black or African American, two or more races, Asian, Native Indian and Alaskan Native, and Native Hawaiian and Other Pacific Islander, respectively.

Clustered Bar Graph of Racial Demographics in the United States and Portland, Oregon

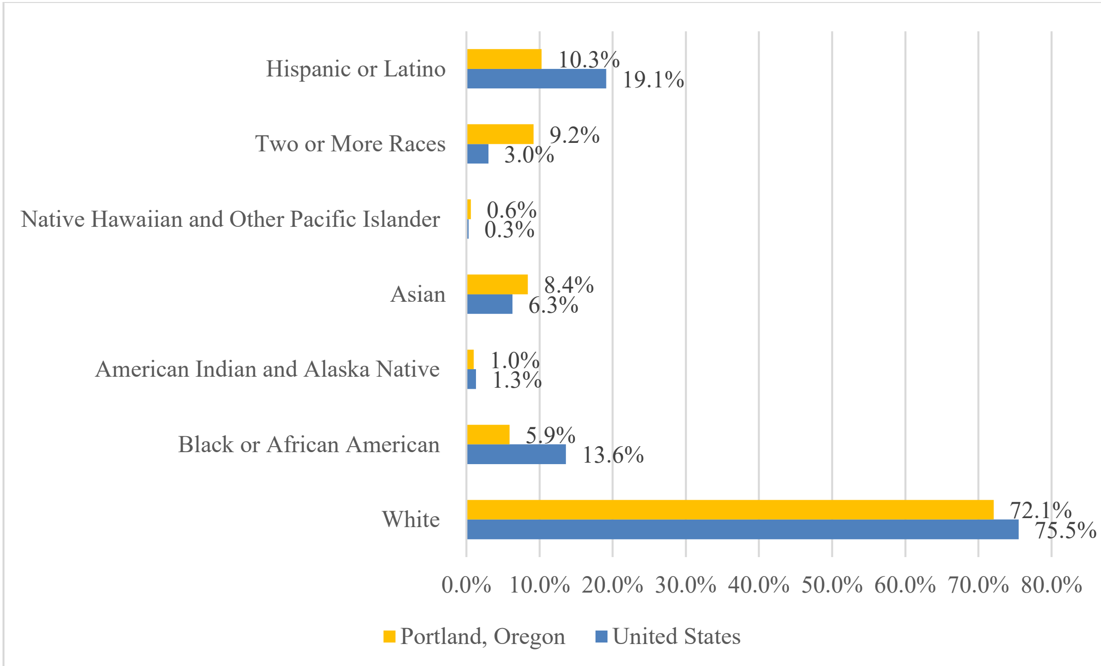

Figure 5: The clustered bar graph reflects the racial demographic in Portland compared to the United States based on data obtained from the United States Census Bureau. The orange represents data on Portland while the blue reflects the data for the United States.

This comparison provides a baseline understanding of how Portland's racial makeup aligns with or deviates from national trends. Using this graph, it can be seen that Portland has a lower percentage of Hispanic or Latino, Black, and White people, and a higher percentage of Asian people than the United States. This graph also emphasizes the importance of context-specific analysis, as local factors might cause variations from the national pattern. This can be crucial for localized urban and UA planning.

Race and Ethnicity Score Map and Bar Graph

By displaying the race and ethnicity score of Portland, Oregon through a color value spectrum, Figure 6 provides a visual representation of the race clustering and their relation to UA plot locations. This map reveals that most of the UA sites are clustered towards the center of

Portland, and there are few UA sites in the northernmost large neighborhoods, few in the west, and relatively few in neighborhoods that are colored white.

Map of UA Plots and Race and Ethnicity Score in Portland, Oregon

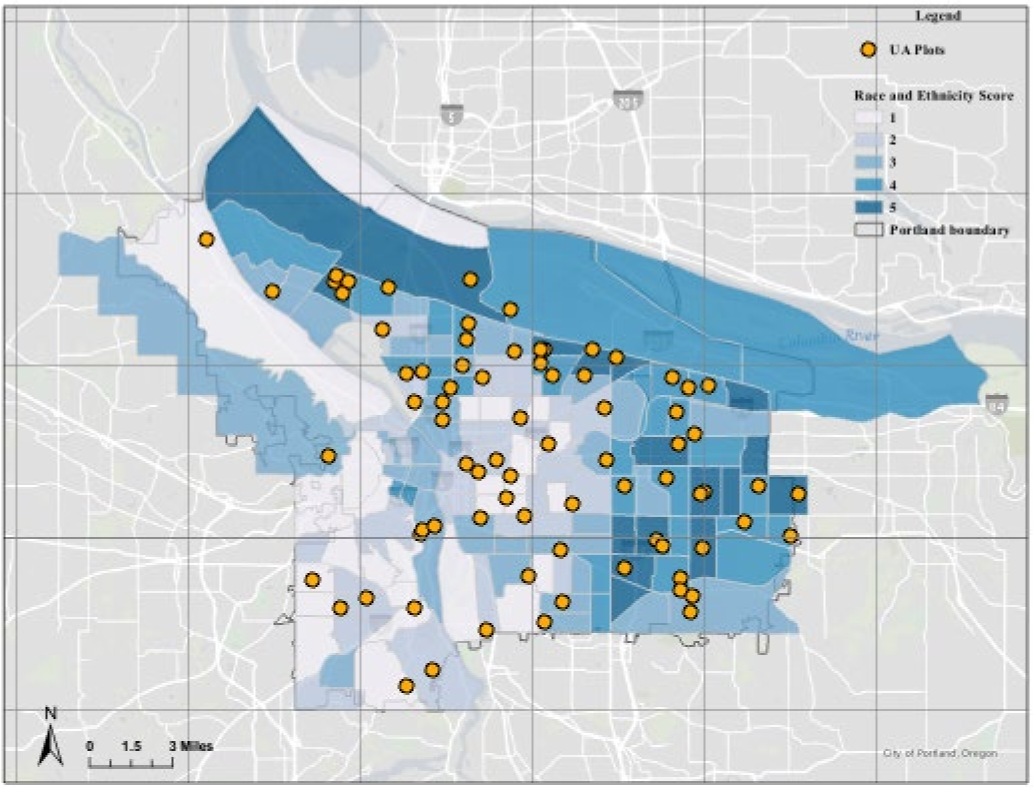

Figure 6: This map illustrates the visual placement of UA plots in Portland in relation to the race and ethnicity score assigned to each neighborhood. A higher score on the diversity and ethnicity score reflects a greater percentage of citizens who self-identified as persons of color or Latinx (of any race) in the U.S. Census; 1 represents the lowest degree of diversity (0–20%) and 5 represents the highest level of diversity (80–100%) on this map.

For a quantitative reflection of the data, a bar graph was created (Fig. 7). In this data, the following observations can be made: 6 UA plots in the areas with a race and ethnicity score of 1 (low relative diversity), 15 UA plots in the areas with a race and ethnicity score of 2, 19 UA plots in the areas with a race and ethnicity score of 3, and 20 UA plots in the areas that have an ethnicity score of 4 or 5 (high relative diversity). Based on this, 50% of the plots in Portland are located in areas that are deemed to have a high race and ethnicity score (either 4 or 5).

Meanwhile, only 26% of the UA plots are located in areas with low race and ethnicity scores (1 and 2).

Bar Graph of Plot Location in Relation to the Race and Ethnicity Score of Neighborhoods in Portland, Oregon

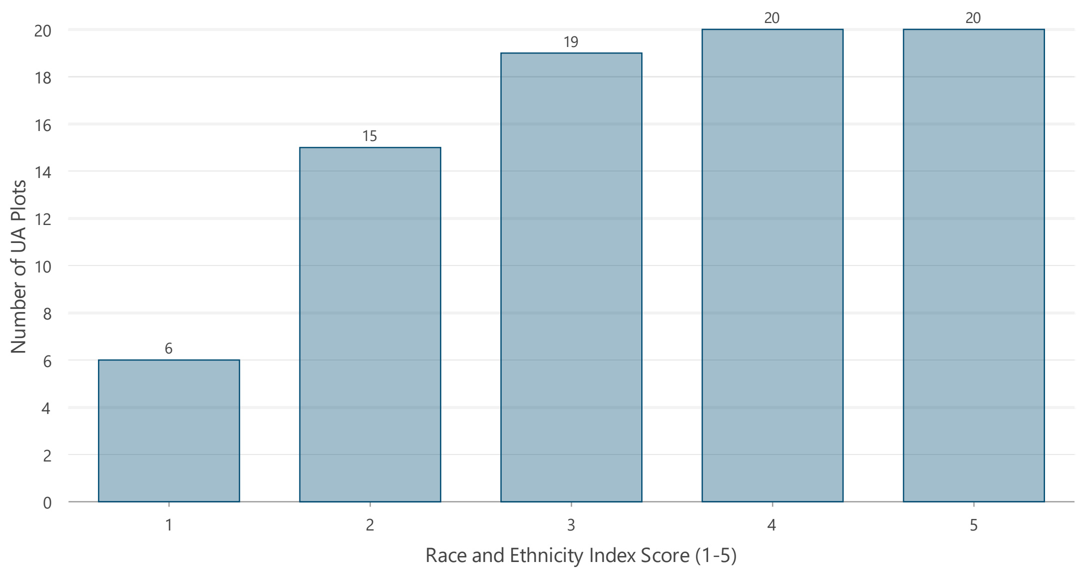

Figure 7: This bar chart reflects the relationship between UA plots and the assigned race and ethnicity score of neighborhoods in Portland, Oregon to help analyze the data. 1 on the Race and Ethnicity Index Score represents the lowest level of diversity (0-20%) while 5 represents the highest level of diversity (80-100%).

Equity

Median Household Income Map

As shown in Figure 8, the median household income and UA plot placement is displayed on a map. In this map, 187 houses were observed, and it was found that the minimum median household income is $21,781, the maximum median household income is $198,500, the mean median household income is $86,761.98, and the standard deviation is $33,653.91. Looking at the map, the neighborhoods with clusters of smaller houses in the east of Portland's boundary have lower median household incomes than the areas with larger houses that are more spread apart in the west of Portland.

Map of the UA Plot Locations and Median Household Income in Portland, Oregon

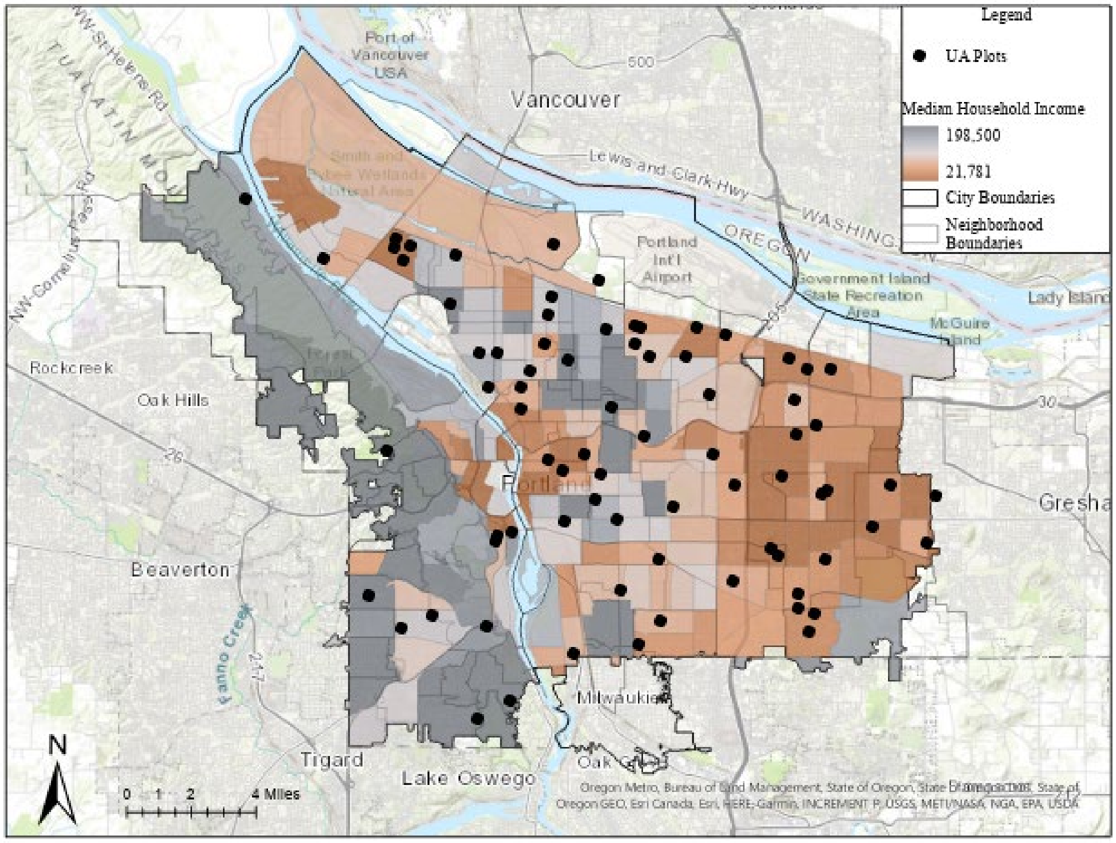

Figure 8: This map reflects the median household income and UA plot locations through a color scale. With an orange to grey color scheme with orange reflecting cheaper household incomes and grey showcasing more expensive household incomes, this map shows the relationship between UA plots and the median household income in Portland. The black dots symbolize the UA plots.

Median Household Income Histogram

For a quantitative review of the data, a histogram was created to analyze the correlation between median household income and UA plot placement (Fig. 9). Based on this graph, the mean median household income of neighborhoods that have UA is approximately $80,200 with a right-skewed normal distribution. With the mean median household income being $86,761.98, this figure reveals that UA is located in areas that experience an average of $6,562 less median household income. Based on this, it can be assumed that UA is placed in affluent areas in Portland.

Histogram of UA Plot Locations Compared to Median Household Income in Portland, Oregon

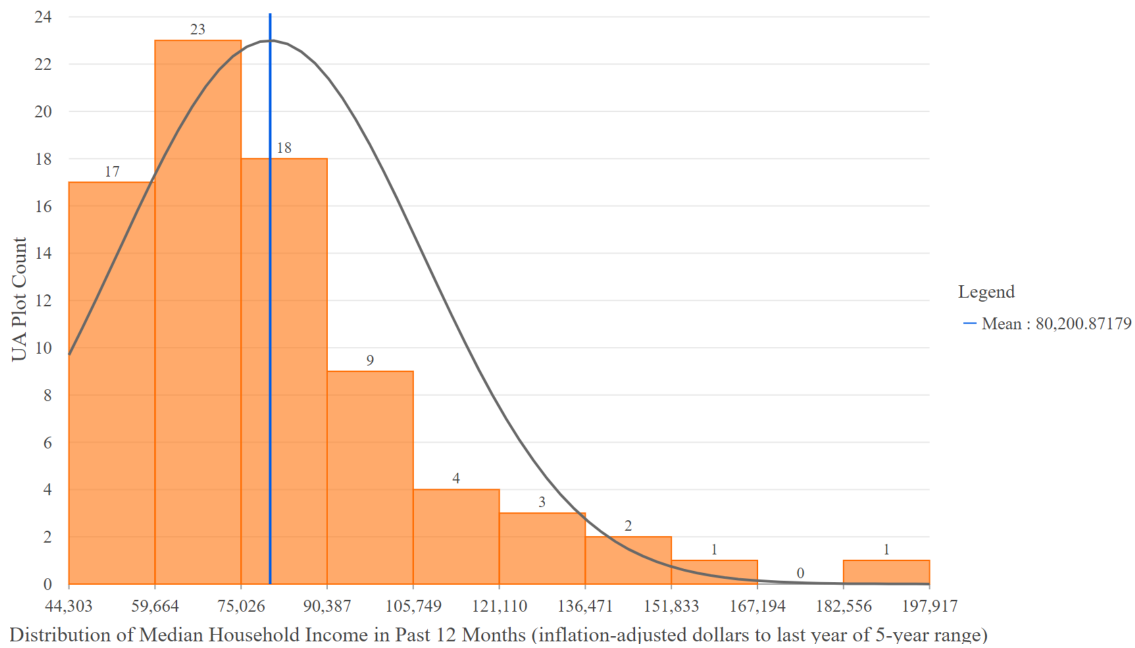

Figure 9: This histogram shows the median household income in the past 12 months and UA plot count. For accuracy, it considers the inflation-adjusted dollars to the last five-year range. The mean is symbolized by the vertical blue line while the normal distribution is shown by the curved black line.

Inclusion

Public vs Private Map

Using the basemap, this map was derived to illustrate the private versus public UA plots (community gardens, community farms, and rooftop gardens) in the Portland area (Fig. 10). Marking plots as either red for private or green for public, this map illustrates that the majority of the plots are public with a few private plots on the outskirts of the city. This is to be expected since the UA analyzed were community farms, urban farms, and rooftop gardens. Out of the 80 plots observed, approximately 67 of them were community farms and accessible to the community.

Map of Private and Public UA Plots in Portland, Oregon

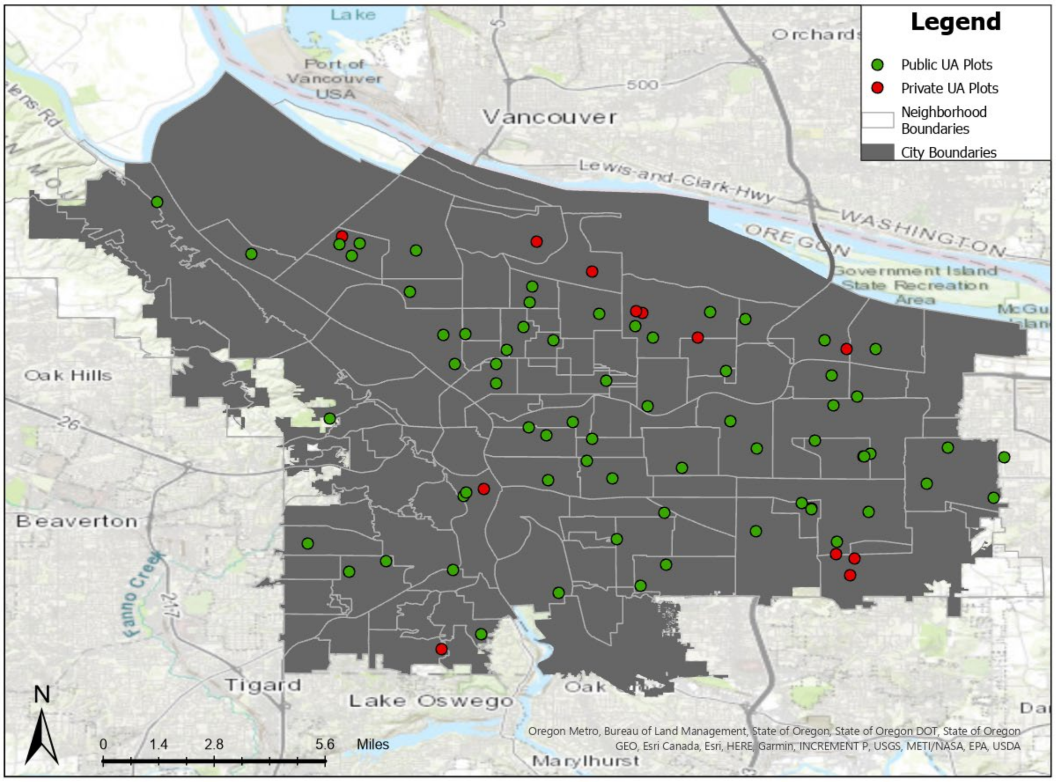

Figure 10: This map highlights the private (red) and public (green) UA plots in Portland, Oregon.

Public vs Private Pie Chart

To further analyze the number of private and public UA plots, a pie chart was designed (Fig. 11). Revealing that 85% of the plots in Portland are public while only 15% are private, there is a clear contrast with more UA being accessible to the general public.

Pie Chart of Private and Public UA Plots in Portland, Oregon

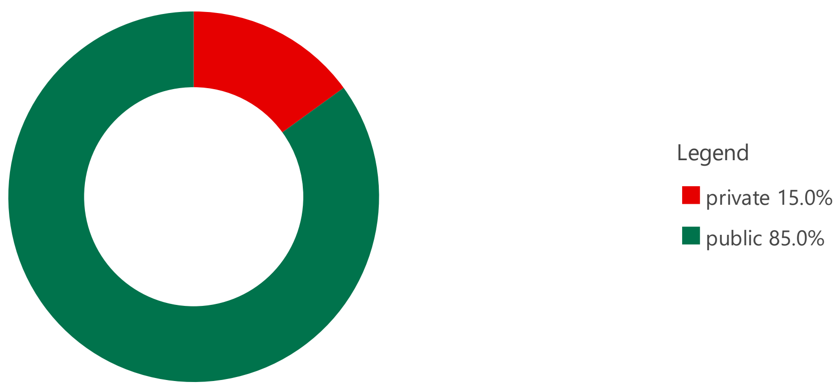

Figure 11: This pie chart highlights the private (red) and public (green) UA plots in Portland, Oregon.

Environmental Justice

Environmental Hazard Index Map

To assess the environmental conditions, Figure 12 plots UA from the basemap (orange), the eco-roofs (green), and the environmental hazards index in Portland. Clustered in the center of the city, the eco-roofs and UA appear to reside in areas that are slightly more hazardous. Environmental hazards consider topographic wetness and UHI. Areas that are more likely to experience nuisance flooding are indicated by topographic wetness, while UHIs are defined as areas with higher temperatures than their rural surroundings. The cumulative effect of many environmental stressors determines the total hazard potential; deeper blue indicates a lower hazard potential and red indicates a larger hazard potential.

Map of UA with Eco-Roofs and the Environmental Hazard Index in Portland, Oregon

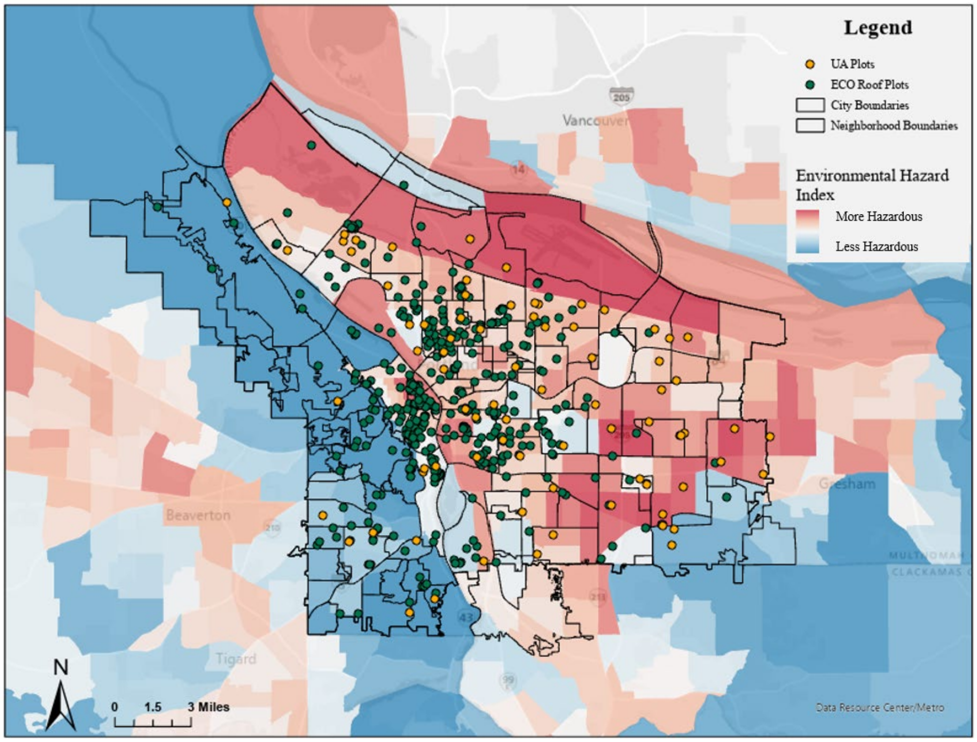

Figure 12: Depiction of UA plots (including community gardens, community farms, rooftop gardens, and eco-roofs) on a map that reflects the environmental hazard index in Portland, Oregon.

Urban Heat Island Map and Histogram

Figure 13 was produced to narrow the scope on these environmental hazards and focus solely on UHI in Portland. This map overlays the UA basemap plots and the eco-roofs with a color scheme to depict the effect of UHI in Portland through its deviation from regional average temperatures. This map reveals that, similarly to the environmental hazard map, the UA plots are primarily located in areas that experience a 0-2 degrees Fahrenheit warmer (yellow) and 2-4 degrees Fahrenheit warmer (orange). Furthermore, the data represents a normal distribution that is skewed to the left.

Map of UA with Eco-Roofs and UHI Index in Portland, Oregon

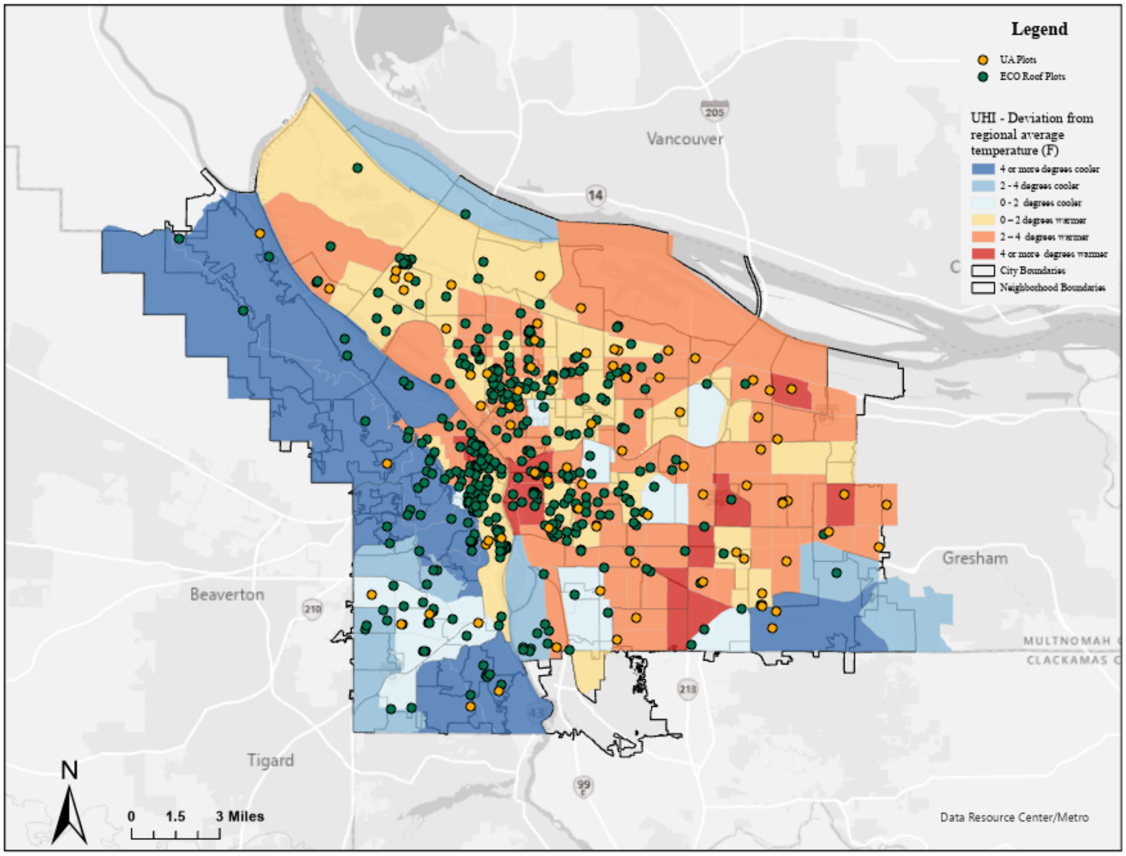

Figure 13: Depiction of UA plots (including community gardens, community farms, rooftop gardens, and eco-roofs) on a map that reflects the UHI index and regional deviation from the average temperature in Portland, Oregon.

To further analyze these findings, a histogram was configured to display the UHI effect in relation to plot location (Fig. 14). With a mean of 1.148 in a range from -9.2 to 4.1, there are more UA plots located in areas that experience higher temperature deviations than the average. This gives the data a left-skewed normal distribution.

Histogram of UA with Eco-Roofs and UHI Index in Portland, Oregon

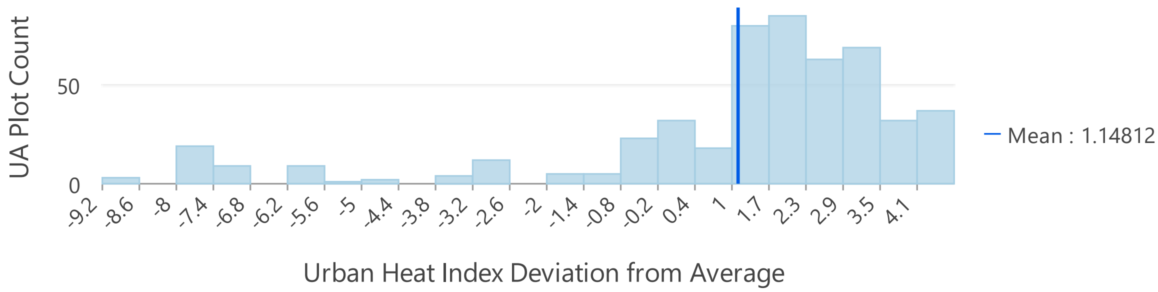

Figure 14: Histogram depicting the relationship between UA plots (including community gardens, community farms, rooftop gardens, and eco-roofs) and the urban heat index deviation from the average in Portland to assess the relationship between UA and UHI.

To conclude, these results reflect that, compared to places with less UA plots, it is expected that areas with a higher concentration of UA plots will show increased racial and ethnic variety, decreased income inequality, better access to agricultural resources, and improved environmental advantages.

Chapter 5: Discussion

This section delves into the implications and significance of the findings from the results section and explores the interconnected relationship between UA and DEIJ in Portland, Oregon.

Diversity

With a population of over 500,000, Portland continues to be the whitest American city in spite of the country's increasing ethnic diversity (Woody, 2021). This is highlighted in Figure 4 with the abundance of yellow dots in the dot density map that depicts racial diversity as well as the statistics in Figure 5 revealing Portland to be 72.1% white. However, in the bar graph (Fig. 7) that was created using the Race and Ethnicity Map (Fig. 6), it was found that 50% of the plots in Portland are in areas that are deemed to have a relatively high race and ethnicity score (either 4 or 5). Meanwhile, only 26% of the UA plots shown in Figure 7 are located in areas with relatively low race and ethnicity scores (1 and 2). Thus, despite the city's history of racial violence and exclusion, this data (Fig. 5) supports the idea that Portland has become a place where minorities (including but not limited to Hispanic or Latinx, Asian Americans, Native Americans, American Indian, Alaskan Native, Pacific Islanders, and African Americans) are starting to create a sense of community (Woody, 2021). Based on these results, it can be asserted that Portland has been successful in distributing UA in locations that reflect a certain degree of diversity.

Unfortunately, this issue is slightly more complex due to Portland's history of gentrification. For instance, numerous studies have criticized UA sustainability efforts, arguing that it could exacerbate displacement and fail to ensure the wellbeing of all residents in areas where green and sustainability initiatives are put into practice (Bunce, 2009; Cucca, 2012; Dooling, 2009; Gould and Lewis, 2017; McClintock, 2020; Quastel, 2009). This has been shown in community gardens in Portland, which ironically, have the potential to worsen gentrification by drawing middle-class white residents and maintaining (intentionally or unintentionally) barriers that frequently prevent persons of color (McClintock, 2020). By increasing property values in nearby communities, community gardens have a negative impact on gentrification (McClintock, 2020). As a result, it becomes crucial to continue research on diversity and UA within Portland to understand the long-term impacts of these UA initiatives.

Equity

Previous studies point to a clear trend in UA that implies states with communities of low-income groups purposely develop more gardens in those areas to combat the inequity in food availability (Butterfield, 2020; Campbell 2017; Reynolds 2015; Reynolds and Cohen 2016; White 2017). Figures 8 and 9 support these findings by presenting a clear correlation between UA distribution and the distribution of median household incomes in the past 12 months throughout Portland. As shown in Figure 9, the distribution of UA is strongly skewed to the right, indicating that most of the neighborhoods with UA live in less wealthy areas. This trend shows how Portland has used UA programs in creative ways to increase food equity with success. By focusing on low-income areas, the city not only addresses food deserts but also provides fresh produce to residents and opens doors for both social and economic engagement. These urban farms and gardens therefore have a great chance to increase food security by providing affordable, healthy food options where they are most needed. Furthermore, this strategy shows a dedication to social equality by recognizing and addressing the structural inequities that commonly limit access to nutritious food options. Using this logic, it can be stated that Portland has been successful in distributing UA in locations that reflect a certain degree of equity.

However, similarly to analyzing the diversity in Portland, it is not this simple due to the concept of eco-gentrification. Since its introduction to the US in the 1970s, gentrification has been the subject of investigation (Schrup, 2019). In 2009, a new term known as ecological gentrification (or eco-gentrification) emerged from housing, economic, health, and cultural gentrification (Schrup, 2019). A subset of gentrification, it is defined as:

> "The implementation of an environmental planning agenda related to public green spaces that leads to the displacement or exclusion of the most economically vulnerable human population … while espousing an environmental ethic. Ecological gentrification is a provocative term that highlights the contradictions that emerge between an ecological rationality and its associated environmental ethics, and the production of injustices for politically and economically vulnerable people" (Dooling 2009).

Simply put, eco-gentrification is the entry of middle-class people into mostly lower-class areas due to the introduction of environmental policies and initiatives. Similarly to the negative impact that gentrification had on differing racial demographics, eco-gentrification can have a harmful effect on lower-income neighborhoods in Portland. Thus, in order to comprehend the long-term effects of these UA activities, it is imperative that research on economic equity and UA placement in Portland be conducted going forward.

Inclusion

The next aspect of DEIJ that is analyzed is inclusion. Based on the results from Figure 11, 85% of the plots in Portland are public while only 15% are private. Additionally, Figure 10 shows that the majority of the plots that are public are located closer to the center of the city with a few private plots on the outskirts. This level of inclusion is due to Portland's commitment to introducing accessible UA through its municipal support, policy framework, community organizations, and nonprofits. Whether it is Portland Parks and Recreation (PP&R) creating and maintaining 60 community gardens since 1975, the Grow Portland transforming underused land into 10 UA plots in the lowest income and most diverse areas of Portland, Friends of Portland Community Gardens (a 501(c) nonprofit organization) supporting UA opportunities, or the plethora of volunteers working to create and preserve plots, Portland is successful in creating UA plots that are inclusive to the general public (Community, n.d.; Friends, 2017; Grow, n.d.). Based on these results, it can be asserted that Portland has been successful in maintaining UA that reflects a high degree of inclusion.

Justice

Through the lenses of environmental risks and the UHI effect in Figures 12, 13, and 14, an examination of Portland's UA plots (including community gardens, urban farms, and rooftop gardens, and eco-roofs) provides vital insights into the geographical distribution and significance of these green areas. In the two maps focused on environmental justice (Fig. 12 and Fig. 13), the areas that experience high risks displayed by both the environmental hazard index and the UHI index also had the most UA. This was highlighted by the histogram (Fig.14) that displayed the correlation between the urban heat index deviation from the average and the number of plots located in the corresponding area. This data showed that there are more UA plots in regions with greater temperature variances than the average (with a mean of 1.148 in a range of -9.2 to 4.1). Based on the causes of UHI, it can be assumed that the areas with higher temperatures and hazard risks are prone to suffering from substantial human traffic, extensive pollution, and greater infrastructure density since these areas are usually metropolitan centers that are subjected to elevated levels of industrial activity that induce heightened pressures on the environment.

Positioned in areas of slightly higher risk, both in terms of hazards and UHI, the UA in Portland experiences both advantages and disadvantages in terms of justice. One way that increasing UA in these high-risk locations can help is by enhancing air quality and lessening the impact of the UHI effect by increasing vegetation. However, it also situates UA initiatives in areas where the environment could make them less sustainable and effective.

To synthesize, the results support the premise that, from a sustainability perspective, Portland upholds a good reputation in terms of UA implementation and DEIJ principles. However, the notion that there are hidden complexities and considerations that must be made when analyzing DEIJ implications is also supported and the need for future research to better understand the long-term impacts of UA is further highlighted.

Chapter 6: Conclusion

In conclusion, UA has become an important discourse within the field of environmental science as mounting global crises arise due to growing urbanization. Heavily contributing to the recent surge of UA both in literature and real-life practice, there has been a renewed emphasis on UA as a dynamic and adaptable solution to urban-induced challenges (Nogeire-McRae et al., 2018; Pulighe and Lupia, 2020; Yoshida and Yagi, 2021). As a result, UA has emerged as a key area of focus due to its innovative and transformative nature and its potential to contribute to resilient and sustainable cities.

To summarize, there are many facets of UA in literature that are necessary to understand its rising relevance in the world; this includes its recent surge, global trends, and connection to the three pillars of sustainability—social, economic, and environmental. This recent surge is highlighted by current research trends, where the number of literary works that mention UA has risen exponentially, and the most influential countries in UA research are the United States, Germany, the United Kingdom, Italy, and China (Yan et al., 2022). These literary works and countries both play an important role in shaping the trajectory of global research. Additionally, research reveals that UA and rural agriculture are interdependent upon the other since they have the power to influence how independent cities are from rural agriculture in terms of food supply. Even while UA is not likely to make cities completely self-sufficient in terms of food, a number of studies show that UA can contribute to food security. There is also a plethora of existing research that emphasizes UA's connection to the three pillars of sustainability: social, economic, and environmental. One of the most prominent findings within literature focusing on the sustainability of UA is that there are both benefits and disadvantages of UA within these three pillars that need to be considered. It is crucial to understand both sides of UA before attempting to implement agriculture into urbanized environments.

Building on previous research, this study identifies a knowledge gap regarding the implications of UA and DEIJ and utilizes ArcGIS Pro to conduct a case study in Portland, Oregon communities to evaluate UA from the perspectives of race, economy, accessibility, and the environment. The findings can be summarized as follows. From a racial and ethnic aspect, UA in Portland is located in predominantly ethnically diverse communities. Based on statistics on median household income in Portland communities, an economic perspective found that UA was most widespread in less wealthy locations. To evaluate inclusion, it was discovered that UA plots are largely available to the general public. Finally, from an environmental perspective, the distribution of UA was often found in neighborhoods with greater risk factors as indicated by both the environmental hazard score and the UHI index.

However, using both the literature review and the findings from the case study in Portland, Oregon, it can be concluded that while Portland upholds many of the DEIJ principles through the implementation and placement of UA, many of these issues have complexities that require future research regarding the long-term impacts between UA and DEIJ. Whether it is issues of gentrification, eco-gentrification, or urban-induced environmental challenges, there are myriad facets of UA that must be further analyzed to ensure that UA practices do not inadvertently perpetuate inequities associated with DEIJ components.

Thus, this thesis is merely a step towards understanding the potential of UA. As urbanization continues to rise at a rapid pace and access to rural farmland decreases, UA is evolving from less of an option and more of a necessity.

To fully utilize UA as an innovative method for creating fundamentally egalitarian and sustainable urban communities, it will be imperative to address these issues and continue to add to the exponential growth of knowledge surrounding this revolutionary practice.

Bibliography

Ackerman, K., Dahlgren, E., & Xu, X. (2012). Sustainable Urban Agriculture: Confirming Viable Scenarios for Production. Prepared for the New York State Energy Research and Development Authority.

Ackerman, K., Conard, M., Culligan, P., Plunz, R., Sutto, M. P., & Whittinghill, L. (2014). Sustainable food systems for future cities: The potential of urban agriculture. The economic and social review, 45(2, Summer), 189-206.

Alaimo, K., Reischl, T. M., & Allen, J. O. (2010). Community gardening, neighborhood meetings, and social capital. Journal of community psychology, 38(4), 497-514.

Alexandri, E., & Jones, P. (2008). Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates. Building and environment, 43(4), 480-493.

Armanda, D. T., Guinée, J. B., & Tukker, A. (2019). The second green revolution: Innovative urban agriculture's contribution to food security and sustainability–A review. Global Food Security, 22, 13-24.

Barron, J. (2017). Community gardening: Cultivating subjectivities, space, and justice. Local Environment, 22(9), 1142-1158.

Bates, L., & Curry-Stevens, A. Coalition of Communities of Color (2014). The African-American community in Multnomah county: An unsettling profile. Portland, OR: Portland State University.

Berndtsson, J. C. (2010). Green roof performance towards management of runoff water quantity and quality: A review. Ecological engineering, 36(4), 351-360.

Berndtsson, J. C., Emilsson, T., & Bengtsson, L. (2006). The influence of extensive vegetated roofs on runoff water quality. Science of the Total Environment, 355(1-3), 48-63.

Billings Jr, D. R. (2018). White space, black space: Community gardens in Portland, Oregon.

Birch, E. L., & Wachter, S. (Eds.). (2008). Growing greener cities: Urban sustainability in the twenty-first century. University of Pennsylvania Press.

Bunce, S. (2009). Developing sustainability: sustainability policy and gentrification on Toronto's waterfront. Local Environment, 14(7), 651-667.

Burke, L. N., & Jeffries, J. L. (2016). The Portland Black Panthers: empowering Albina and remaking a city. University of Washington Press.

Butterfield, K. L. (2020). Neighborhood composition and community garden locations: The effect of ethnicity, income, and education. Sociological Perspectives, 63(5), 738-763.

Campbell, L. K. (2017). City of forests, city of farms: Sustainability planning for New York City's nature. Cornell University Press.

Campbell, N. (2017). Farming cities: the potential environmental benefits of urban agriculture. DU Quark, 2(1), 3-16.

Community gardens. (n.d.). Portland.Gov. Retrieved May 18, 2024, from https://www.portland.gov/parks/community-gardens.

Cruz, N., Rodrigues, S.M., Coelho, C., Carvalho, L., Duarte, A.C., Pereira, E., Romkens P.F.A.M. (2014) Urban agriculture in Portugal: Availability of potentially toxic elements for plant uptake. Applied Geochemistry 44, 27-37.

Cucca, R. (2012). The unexpected consequences of sustainability. Green cities are between innovation and ecogentrification. Sociologica, 6(2), 0-0.

Cutter, S. L. (1995). Race, class and environmental justice. Progress in human geography, 19(1), 111-122.

Dalley, S. (1993). Ancient Mesopotamian gardens and the identification of the hanging gardens of Babylon resolved. Garden History, 1-13.

Deelstra, T., & Girardet, H. (2000). Urban agriculture and sustainable cities.

Dias-Ferreira, Ferreira, A.J.D., C., Pato, R.L., Varejão, J.B., Tavares, A.O. (2016) Heavy metal and PCB spatial distribution pattern in sediments within an urban catchment—contribution of historical pollution sources. J Soils Sediments 16, 2594–2605

Diekmann, L. O., Gray, L. C., & Thai, C. L. (2020). More than food: The social benefits of localized urban food systems. Frontiers in Sustainable Food Systems, 4, 534219.

Dimitri, C., Oberholtzer, L., & Pressman, A. (2016). Urban Agriculture: Connecting Producers with Consumers. British Food Journal, 118(3), 603–617.

Dooling, S. (2009). Ecological gentrification: A research agenda exploring justice in the city. International journal of urban and regional research, 33(3), 621-639.

Ebissa, G., & Desta, H. (2022). Review of urban agriculture as a strategy for building a water resilient city. City and Environment Interactions, 14, 100081.

Emilsson, T., Berndtsson, J. C., Mattsson, J. E., & Rolf, K. (2007). Effect of using conventional and controlled release fertiliser on nutrient runoff from various vegetated roof systems. Ecological engineering, 29(3), 260-271.

Eom, K. C., Jung, P. K., Park, S. H., Yoo, S. Y., & Kim, T. W. (2012). Evaluation of the Effect of Urban-agriculture on Urban Heat Island Mitigation. Korean Journal of Soil Science and Fertilizer, 45(5), 848-852.

Ernwein, M. (2014). Framing urban gardening and agriculture: On space, scale and the public. Geoforum, 56, 77-86.

Ferreira, A.J.D., Dias-Ferreira, C., Ferreira, C.S.S., Serrano, L.M.V., Walsh, R.P.D. (2016) Roads as sources of heavy metals in urban areas. The Covões catchment experiment, Coimbra, Portugal. J Soils Sediments 16, 2622–2639.

Feng, B., Zhang, Y., & Bourke, R. (2021). Urbanization impacts on flood risks based on urban growth data and coupled flood models. Natural Hazards, 106(1), 613-627.

Fletcher, E. I., & Collins, C. M. (2020). Urban agriculture: Declining opportunity and increasing demand—How observations from London, UK, can inform effective response, strategy and policy on a wide scale. Urban forestry & urban greening, 55, 126823.

Friends of Portland Community Garden. (2017, June 10). Friends of Portland Community Gardens | Helping Grow Portland's Community Gardens Through Services And Advocacy Since 1985. https://portlandcommunitygardens.org/about/.

Galea, S., Ettman, C. K., & Vlahov, D. (2019). The Present and future of cities. Urban Health, 1.

Garnett, T., M.C. Appleby, A. Balmford, I.J. Bateman, T.G. Benton, P. Bloomer, B. Burlingame, M. Dawkins, L. Dolan, D. Fraser, M. Herrero, I. Hoffman, P. Smith, P.K. Thornton, C. Toulmin, S.J. Vermeulen, and H.C.J. Godfray. (2014). Sustainable intensification in agriculture: Premises and policies. Science 341:33–34.

Getter, K. L., & Rowe, D. B. (2009). Substrate depth influences Sedum plant community on a green roof. HortScience, 44(2), 401-407.

Getter, K. L., Rowe, D. B., & Andresen, J. A. (2007). Quantifying the effect of slope on extensive green roof stormwater retention. Ecological engineering, 31(4), 225-231.

Gibson, K. J. (2007). Bleeding Albina: A history of community disinvestment, 1940-2000. Transforming Anthropology, 15(1), 3-25.Glover, T. D. (2004). Social capital in the lived experiences of community gardeners. Leisure Sciences, 26(2), 143-162.

Glenn PhD, I., & Elswick, J. L. (2020). Diversity, Equity and Inclusion Terms and Definitions.

Goodling, Erin, Jamaal Green, & Nathan McClintock. (2015). "Uneven Development of the Sustainable City: Shifting Capital in Portland, Oregon." Urban Geography 36(4)504-527.

Gould, K., & Lewis, T. (2016). Green gentrification: Urban sustainability and the struggle for environmental justice. Routledge.

Graefe, S., Schlecht, E., & Buerkert, A. (2008). Opportunities and challenges of urban and peri-urban agriculture in Niamey, Niger. Outlook on agriculture, 37(1), 47-56.

Grow portland community gardens. (n.d.). Grow Portland. Retrieved May 18, 2024, from https://www.growportland.org/community-gardens.

Hansmann, R., Mieg, H. A., & Frischknecht, P. (2012). Principal sustainability components: empirical analysis of synergies between the three pillars of sustainability. International Journal of Sustainable Development & World Ecology, 19(5), 451–459. https://doi.org/10.1080/13504509.2012.696220.

Hathaway, A. M., Hunt, W. F., & Jennings, G. D. (2008). A field study of green roof hydrologic and water quality performance. Transactions of the ASABE, 51(1), 37-44.

Hern, M. (2016). What a City is for: Remaking the Politics of Displacement. MIT Press.

Hilaire, R.S., M.A. Arnold, D.C. Wilkerson, D.A. Devitt, B.H. Hurd, B.J. Lesikar, V.I. Lohr, C.A. Martin, G.V. McDonald, R.L. Morris, D.R. Pittenger, D.A. Shaw, and D.F. Zoldoske. 2008. Efficient water use in residential urban landscapes. HortScience 43:2081–2092.

Kouvonou, F.M., B.G. Honfoga and S.K. Debrah (1998). Security alimentaire et gestion integree de la fertilite des sols: contribution du maraichage peri-urbain a Lome." In Agriculture urbaine en Afrique de l'Ouest: Une contribution a la securite alimentaire et a l'assainissement des villes, pp. 83-103. Edited by Olanrewaju B. Smith. Technical Centre for Agricultural and Rural Cooperation and International Development Research Centre, Ottawa.

Langemeyer, J., Madrid-Lopez, C., Beltran, A. M., & Mendez, G. V. (2021). Urban agriculture—A necessary pathway towards urban resilience and global sustainability?. Landscape and Urban Planning, 210, 104055.

Liao, H., Tang, M., Luo, L., Li, C., Chiclana, F., & Zeng, X. J. (2018). A bibliometric analysis and visualization of medical big data research. Sustainability, 10(1), 166.

Liptan, T., Arpels, M., Chrisman, S., Sommerfield, H., Towers, J., Berkowitz, E., ... & Hickey, L. (2005). Portland: A new kind of stormwater management. Earthpledge. Green roofs: Ecological design and construction, 121-123.

Marçal, D., Mesquita, G., Kallas, L. M., & Hora, K. E. R. (2021). Urban and peri-urban agriculture in Goiânia: The search for solutions to adapt cities in the context of global climate change. Urban Climate, 35, 100732.

Maxwell, Daniel and Maragaret Armar-Klemestt (1998). The Impact of Urban Agriculture on Livelihoods, Food Page 52 of 58 and Nutrition Security in Greater Accra. Presented at IDRC Cities Feeding People Workshop on Lessons Learned from Urban Agriculture Projects in African Cities, Nairobi, June 1998.

Maxwell, Daniel G. (1995) Alternative Food Security Strategy: A Household Analysis of Urban Agriculture in Kampala. World Development 23/10: 1669-16S1.

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

McClintock, N., Mahmoudi, D., Simpson, M., & Santos, J. P. (2016). Socio-spatial differentiation in the Sustainable City: A mixed-methods assessment of residential gardens in metropolitan Portland, Oregon, USA. Landscape and Urban Planning, 148, 1-16.

McClintock, N. (2020). Cultivating (a) sustainability capital: Urban agriculture, ecogentrification, and the uneven valorization of social reproduction. In Social Justice and the City (pp. 279-290). Routledge.

McGlinchy, J., Johnson, B., Muller, B., Joseph, M., & Diaz, J. (2019, July). Application of UNet fully convolutional neural network to impervious surface segmentation in urban environment from high resolution satellite imagery. In IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium (pp. 3915-3918). IEEE.

McIntyre, L., & Snodgrass, E. C. (2010). The green roof manual: a professional guide to design, installation, and maintenance. Timber Press.

Mees, C., & Stone, E. (2012). Zoned out: The potential of urban agriculture planning to turn against its roots. Cities and the Environment (CATE), 5(1), 7.

Moseley, R. A., Barnett, M. O., Stewart, M. A., Mehlhorn, T. L., Jardine, P. M., Ginder-Vogel, M., & Fendorf, S. (2008). Decreasing lead bioaccessibility in industrial and firing range soils with phosphate-based amendments. Journal of environmental quality, 37(6), 2116-2124.

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

Mougeot, L. J. (2000). Urban agriculture: Definition, presence, potentials and risks, and policy challenges. Cities feeding people series; rept. 31.

Nabuloa, G., Oryem-Origab, H., Diamond, M. (2006) Assessment of lead, cadmium, and zinc contamination of roadside soils, surface films, and vegetables in Kampala City, Uganda. Environmental Research 101, 42–52.

Nogeire-McRae, T., Ryan, E. P., Jablonski, B. B., Carolan, M., Arathi, H. S., Brown, C. S., ... & Schipanski, M. E. (2018). The role of urban agriculture in a secure, healthy, and sustainable food system. BioScience, 68(10), 748-759.

Orsini, F., Kahane, R., Nono-Womdim, R., & Gianquinto, G. (2013). Urban agriculture in the developing world: a review. Agronomy for sustainable development, 33, 695-720.

Panigrahi, S. 1995) "Parallels in Dairy and Poultry Development Strategies and Issues Relating to Urbanisation in the Eastern India Region". Natural Resource Institute, Chatham.

Peters, C. J., Bills, N. L., Lembo, A. J., Wilkins, J. L., & Fick, G. W. (2009). Mapping potential foodsheds in New York State: A spatial model for evaluating the capacity to localize food production. Renewable agriculture and food systems, 24(1), 72-84.

Philpott, T. (2010). The history of urban agriculture should inspire its future. Grist Magazine United States of America.

Pimentel, D., Houser, J., Preiss, E., White, O., Fang, H., Mesnick, L., ... & Alpert, S. (1997). Water resources: agriculture, the environment, and society. BioScience, 47(2), 97-106.

Potter, R. L., & Hylton, T. N. (2022). 5.1 Equity, Diversity, and Inclusion: Terminology. Communication Essentials for Business.

Pulighe, G., & Lupia, F. (2020). Food first: COVID-19 outbreak and cities lockdown a booster for a wider vision on urban agriculture. Sustainability, 12(12), 5012.

Qiu, G. Y., Li, H. Y., Zhang, Q. T., Wan, C. H. E. N., Liang, X. J., & Li, X. Z. (2013). Effects of evapotranspiration on mitigation of urban temperature by vegetation and urban agriculture. Journal of Integrative Agriculture, 12(8), 1307-1315.

Quastel, N. (2009). "Quastel Political ecologies of gentrification" Urban Geography, 30 (2009), pp. 694-725

Renner, S. (2016). Top 10 cities in the US for urban farming. Inhabitat. Last modified June, 22.

Reynolds, K. (2015). Disparity despite diversity: Social injustice in New York City's urban agriculture system. Antipode, 47(1), 240-259.

Reynolds, K., & Cohen, N. (2016). Beyond the kale: Urban agriculture and social justice activism in New York City (Vol. 28). University of Georgia Press.

Rodrigues, S.M., C., Cruz, Coelho, N., Henriques, B., Duarte, A.C., Pereira, E., Römkens, P.F.A.M. (2013) Risk assessment for Cd, Cu, Pb and Zn in urban soils: Chemical availability as the central concept. Environmental Pollution 183, 234-242.

Rowe, D. B. (2011). Green roofs as a means of pollution abatement. Environmental pollution, 159(8-9), 2100-2110.

Saldivar-Tanaka, L., & Krasny, M. E. (2004). Culturing community development, neighborhood open space, and civic agriculture: The case of Latino community gardens in New York City. Agriculture and human values, 21, 399-412.

Satterthwaite, D. (2007). The transition to a predominantly urban world and its underpinnings (No. 4). Iied.

Schmelzkopf, K. (1995). Urban community gardens as contested space. Geographical review, 364-381.

Schrup, J. M. (2019). Barriers to Community Gardening in Portland, OR.

Shinew, Kimberly J., Troy D. Glover, and Diana C. Parry. (2004). Leisure Spaces as Potential Sites for Interracial Interaction: Community Gardens in Urban Areas. Journal of Leisure Research 36(3):336-355.

Singh, A., Sharma, R.K., Agrawal, M., Marshall, F.M. (2010) Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. Tropical Ecology 51, 375-387

Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., ... & Dierich, A. (2014). Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. Agriculture and human values, 31, 33-51.

Stevenson, Christopher, assisted by Peter Xavery and Acquline Wendeline (1996). Market Production and Vegetables in the Peri-Urban Area of Dar es Salaam, Tanzania. Urban Vegetable Promotion Project (Ministry of Agriculture and Co-operatives - Deutsche Gesellschaft fur Technische Zusammenarbeit GTZ). UVPP, Dar es Salaam.

Teotónio, I., Silva, C. M., & Cruz, C. O. (2018). Eco-solutions for urban environments regeneration: The economic value of green roofs. Journal of Cleaner Production, 199, 121-135.

U.S. Census Bureau: Portland City, Oregon. (n.d.). https://www.census.gov/quickfacts/portlandcityoregon.

Vagneron, I. (2007). Economic appraisal of profitability and sustainability of peri-urban agriculture in Bangkok. Ecological economics, 61(2-3), 516-529.

Vásquez-Moreno, L., & Córdova, A. (2013). A conceptual framework to assess urban agriculture's potential contributions to urban sustainability: An application to San Cristobal de Las Casas, Mexico. International Journal of Urban Sustainable Development, 5(2), 200-224.

Van Averbeke, W. (2007). Urban farming in the informal settlements of Atteridgeville, Pretoria, South Africa. Water Sa, 33(3).

VanWoert, N. D., Rowe, D. B., Andresen, J. A., Rugh, C. L., Fernandez, R. T., & Xiao, L. (2005). Green roof stormwater retention: effects of roof surface, slope, and media depth. Journal of environmental quality, 34(3), 1036-1044.

Wakefield, S., Yeudall, F., Taron, C., Reynolds, J., & Skinner, A. (2007). Growing urban health: community gardening in South-East Toronto. Health promotion international, 22(2), 92-101.

Wadumestrige Dona, C. G., Mohan, G., & Fukushi, K. (2021). Promoting urban agriculture and its opportunities and challenges—a global review. Sustainability, 13(17), 9609.

White, M. M. (2017). Freedom's seeds: Reflections of food, race, and community development: Voices of the food movement in Detroit. Journal of Agriculture, Food Systems, and Community Development, 7(2), 5-7.

Wei, B.G., Yang, L.S (2010) A review of heavy metal contaminations in urban soils, urban road dusts and agricultural soils from China. Microchemical Journal 94, 99–107

Wolf, C. (2018). Sustainable agriculture, environmental philosophy, and the ethics of food. The Oxford Handbook of Food Ethics, 29.

Woody, A. (2021). Race, Space, and Resistance in America's Whitest Big City (Doctoral dissertation, University of Oregon).

Wortman, S. E., & Lovell, S. T. (2013). Environmental challenges threatening the growth of urban agriculture in the United States. Journal of environmental quality, 42(5), 1283-1294.

Wu, S., Peng, Si., Zhang, X., Wu, D., Luo, W., Zhang, T., Zhou, S., Yang, G., Wan, H., Wu, L. (2015) Levels and health risk assessments of heavy metals in urban soils in Dongguan, China. Journal of Geochemical Exploration 148, 71–78.

Yan, D., Liu, L., Liu, X., & Zhang, M. (2022). Global trends in urban agriculture research: A pathway toward urban resilience and sustainability. Land, 11(1), 117.

Yoshida, S., & Yagi, H. (2021). Long-term development of urban agriculture: Resilience and sustainability of farmers facing the COVID-19 pandemic in Japan. Sustainability, 13(8), 4316.

De Zeeuw, H., S. Guendel and H. Waibel (1999). The Integration of Agriculture in Urban Policies. RUAF Foundation International Workshop on Urban Agriculture: Growing Cities, Growing Food – Urban agriculture on the policy agenda.

Zhang, D., Xu, J., Zhang, Y., Wang, J., He, S., & Zhou, X. (2020). Study on sustainable urbanization literature based on Web of Science, scopus, and China national knowledge infrastructure: A scientometric analysis in CiteSpace. Journal of cleaner production, 264, 121537.