THE GOVERNANCE OF COMMUNITY GARDENS AS COMMONS AND ITS ROLE IN THE SOCIO-ENVIRONMENTAL OUTCOMES OF GARDENING IN AUSTIN, TX

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
A	Actors
AFM	Alternative Food Movement
AFN	Alternative Food Network
APAR	Absorbed Photo-synthetically Active Radiation
CAGC	Coalition of Austin Community Gardens
CASA	Carnegie–Ames–Stanford Approach
CPR	Common-Pool Recourses
CSA	Community Supported Agriculture
ECO	Ecosystems
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station
ET	Evapotranspiration
ESI	Evaporative Stress Index
GIS	Geographic Information System
GS	Governance Systems
I	Interactions
IAASTD	International Assessment of Agricultural Knowledge, Science, and Technology for Development

ISCCP	International Satellite Cloud Climatology Project
LAD	Leaf Angle Distribution
LUE	Light Use Efficiency
MRC	Multicultural Refugee Coalition
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NIR	Near-Infrared
NPP	Net Primary Productivity
O	Socio-Ecological Outcomes
PET	Potential Evapotranspiration
RS	Resource Systems
RU	Resource Units
S	Social, Economic, and Political Settings
SES	Socio-Ecological Systems
SFC	Sustainable Food Center
UGC	Urban Green Commons
UPE	Urban Political Ecology

ABSTRACT

Community gardens represent vacant lots in urban areas with public or private land ownership that community members use primarily for urban agriculture. Community gardens are a product of local alternative food movements that contribute to urban socio-ecological resilience-building (i.e., urban community's ability to address issues of food insecurity, social exclusion, and environmental degradation). Local alternative food movements seek to connect people to the land and to food through urban gardening, farmers' markets, and community-supported agriculture, in contrast to industrial, corporate foods. Many studies associate community gardens with neighborhoods' 'commons'– a natural resource, a property, a practice, or a knowledge that is shared and collectively managed by a group of people for individual and communal benefit. This research studies community gardens in Austin, Texas, as alternative local food movements and argues that community gardens represent different types of commons – biophysical, social, cultural and intellectual. It focuses on: 1) approaches taken to govern community gardens, and 2) socio-environmental outcomes of gardening associated with the implemented models of governance. Social outcomes are represented by the level of gardeners' satisfaction and perceptions of their success. Environmental outcomes represent ecological services provided by gardens as green spaces and expressed through net primary productivity (NPP), which measures carbon sequestration. Both types of outcomes affected by how the gardening process is organized and managed. This research argues that the efficacy of community gardens as different types of commons depends on their commitment to the principles of "ethical action" proposed by the diverse-economies framework that can be incorporated in gardens' goals, values and governance. This study analyzes community gardens as spatial socio-environmental outcomes of organizational structures that reflect the spatially explicit dynamics of power, social and ecological processes existing in Austin, Texas, through the lenses of urban political ecology, Ostrom's socio-ecological systems (SES) framework, and the diverse-economies framework. For the purpose of this research, the word 'spatial' is meant to describe the cohesive patterns and places of social activity, which are also described as 'spatial practice' from Henry Lefebvre's spatial triad. The SES framework reflects both social and natural aspects of community gardening and explains the connection between the governance approaches, gardeners' perception of their success and changes in carbon sequestration. This study employs a mixed-methods approach with a concurrent transformative design, a type of research design when the research process is informed by a theoretical perspective/conceptual model, and the qualitative data are used to explain the results of quantitative analyses. Key informant interviews with managers of community gardens yielded both qualitative and quantitative data. Other quantitative data were acquired from remote sensing imagery from the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and Planet Inc. to derive ecological variables to calculate the amount of biomass for the carbon sequestration model.

CHAPTER I

INTRODUCTION

Alternative local food production has been gaining popularity as area of study by human geographers, political ecologists, and GIS specialists. Considering rapid global urbanization, urban food systems represent a distinct area of research, often as a response to urban poverty, food insecurity (Bedore, 2010), and negative impacts of urbanization on the environment (Kowarik, 1995; McKinney, 2008). Globally, urbanization generates 78 percent of all carbon emissions (Grimm et al., 2008). It is crucial to alleviate the impacts of urbanization on ecosystems and to create a balance between residential and natural spaces. Improving food environments is an important fix for the underlying structure of disinvestment and decline in communities (LeDoux, et al., 2014). Local food movements strive to improve communities' environments through ecological, political, economic, and socio-cultural processes (Jarosz, 2008). This is a study of community gardens as alternative local food movements and urban commons with a focus on the approaches taken to govern them and socio-environmental outcomes of gardening associated with the implemented models of governance.

Community gardens represent vacant lots in urban areas with public or private land ownership that community members use primarily for urban agriculture (Schukoske, 2000). Studies argue that community gardens contribute to urban socio-ecological resilience (Colding and Barthel, 2013). Scholars define socio-ecological resilience as the capacity of a system to adapt or transform in the face of changes, so it can continue to support human well-being (Colding and Barthel, 2013). It includes both the ability of people to sustain and improve the development (for example, innovative research and governing transformations) and the ability of nature to rehabilitate and adapt to the changes. This study analyzes the efficacy of community gardens as sustainable practices that benefit both people and ecosystems. A community garden is a complex system that involves multiple relationships and numerous stakeholders. Therefore, an analysis of community gardens and their socio-environmental benefits must consider the characteristics of neighborhoods and populations as well as power dynamics within the space of the gardens themselves. This study contributes to the existing scholarship by analyzing the success of community gardens and their ecological performance as a function of their governance and the spatial interaction of actors with socio-economic and environmental conditions. It argues that the efficacy of community gardens depends on their commitment to the principles of "ethical action" that can be incorporated in gardens' goals, values and governance.

Many studies associate community gardens with neighborhoods' 'commons'– a natural resource, a property, a practice, or a knowledge that is shared and collectively managed by a group of people for individual and communal benefit (Basu et al., 2017; Gibson-Graham et al., 2013; Teig et al., 2009). A community garden is a public space "in terms of ownership, access, and degree of democratic control" (Ferris, et al., 2001, p. 560). Although gardeners typically work independently on individual plots, the collective actions of community members preserve and maintain the gardens through political activism, fundraising, grant-seeking, up-keep, garbage disposal, etc. (Petrovic et al., 2019). This study argues that community gardens represent different kinds of commons: biophysical, cultural commons, social commons, and knowledge commons, therefore, their success depends on the social value they provide in addition to their physical yield. According to the Diverse Economies framework, the social value of community gardens is produced by collective effort and reflected by the principles of 'ethical action' that characterize the effective governance of commons.

Governance of commons needs to consider the physical environment and specific community characteristics (McGinnis 1999). Governance approaches can range from 'top-down' governance (in which community gardens are fully or partially managed by the municipal government or other external organizations) to 'bottom-up' approaches (in which community gardens are sometimes run by the gardeners and sometimes by external specialists who volunteer or are hired to help) (Fox-Kamper et al., 2018). These models of governance have pros and cons. This study evaluates the success of the governance approaches implemented by several community gardens in Austin, Texas.

Regardless their goals, all community gardens involve the process of gardening - the practice of growing and cultivating useful and ornamental plants, which involves interaction with and transformation of nature resulting in the production of biomass. The gardening activity cannot be performed without human effort. Community gardens are spaces of food production that belong to both natural and social worlds that are interdependent. Social outcomes of gardening (the level of gardeners' satisfaction and their perceptions of garden's success) are affected by garden's productivity. In turn, human efforts contribute to ecological services provided by gardens (carbon sequestration). This study analyzes community gardens as socio-ecological systems using Ostrom's socio-ecological system (SES) framework. The SES framework includes five top-tier variables: resource systems, resource units, governance systems, actors, and outcomes (Figure 2). The SES framework is combined with urban political ecology (UPE) perspectives to investigate the factors that influence socio-environmental outcomes related to community gardening, including dynamics of power (Table 1). These theoretical frameworks seek to understand how the rules and regulation in use, the specific biophysical characteristics of the gardens, and the attributes of the community affect the participation, productivity, and perceptions of success.

Table 1: Frameworks Used and Contribution to the Scholarship

Focus	Frameworks	Contribution to the Scholarship
Community gardens represent biophysical, social, cultural, and intellectual commons	Ostrom's Socio-Ecological Systems Framework (SES) The Diverse Economies Framework	This research starts a discourse on community gardens as social, cultural and intellectual commons, and adds to Elinor Ostrom's and Gibson-Graham's work on commoning
Community gardens represent non-capitalist, diverse economies that create 'community economy' based on the principles of 'ethical action'	The Diverse Economies Framework	Provides a case study that investigates the use of the principles of 'ethical action' in community gardens in Austin
The spatially explicit dynamics of power, social and ecological processes are interdependent in community gardens	Urban Political Ecology Framework (UPE) Ostrom's Socio-Ecological Systems Framework (SES)	Illustrates that social and ecological outcomes of community gardens need to be analyzed in tandem because of their co-dependence
Governance of community gardens as commons affects their socio-ecological outcomes	Ostrom's Socio-Ecological Systems Framework (SES)	Utilizes Ostrom's SES conceptual model in community gardening analysis and proposes new variables

The spatial interaction of actors with networks, political, social, and environmental conditions determine the models of governance	Urban Political Ecology Framework (UPE) Ostrom's Socio-Ecological Systems Framework (SES)	Provides specific recommendations to improve organization and management of community gardens in Austin

This research expands the discourse around community gardens as commons. Scholars have discussed community gardens as biophysical or urban green commons emphasizing their role as urban agriculture (Gibson-Graham et al., 2013; Teig et al., 2009; Colding and Barthel, 2013). Barthel et al. (2010) discuss the gardens' contribution to social-ecological memory, however, they do not use the concept of intellectual commons. This research argues that community gardens represent several kinds of commons: *biophysical, social, cultural, and intellectual or knowledge commons*. Peter Linebaugh in his book, The Magna Carta Manifesto: Liberties and Commons for All (2008) argues that "the commons is an activity, and […] it expresses relationships in society that are inseparable from relations to nature" (Linebaugh 2008, p. 279). In community gardens, social and ecological aspects are interdependent and exist only in tandem. Therefore, social and environmental outcomes of community gardening depend on each other and result from the organized collective effort. This dissertation advances the investigation of governance of the commons and the effects of governance approaches on socio-ecological systems (the SES framework).

Urban political ecology integrates the social, ecological, and political processes that create uneven outcomes (Paulson et al., 2003). Political processes in community gardens are expressed through the distribution of power and the governance structure of the gardens: Who is involved in decision-making? Who creates rules and regulations? Community gardens provide a space to negotiate, find consensus, make decisions, and create and implement the rules. A community garden is a system where the gardeners, other people, and the natural world are interdependent. The governance approach determines what forms this interdependence would take. The productivity of gardening depends on the cumulative input of ecological factors (sunlight, rain, and soil), the application of seeds, tools, and fertilizer, and the human factor (volunteer efforts of community gardeners). These factors have a direct influence on carbon sequestration measured by net primary productivity (NPP), which is the difference between the absorbed and released carbon dioxide (NASA, 2011). On the other hand, the efficacy of human efforts depends on how the garden's activities are organized and governed. As a result, the governance of community gardens indirectly influences NPP. This research attempts to estimate NPP by using high-resolution satellite imagery.

This analysis, however, does not necessarily tie the success of a community garden to its capacity to sequester carbon. The human factor is important in carbon uptake because gardeners determine the amounts and types of biomass that is planted. Dennis and James (2016) emphasize the significance of stakeholder participation in environmental stewardship of urban green spaces and its contribution to the adaptive capacity of social-ecological systems. In community gardens, environmental stewardship is carried out by the decision-makers. Based on the model of governance, the decision-makers can be the gardeners, managers, external organizations, or a local government (McGlone et al., 1999; Fox-Kämper et al., 2018). The governance of the community gardens as neighborhood's commons determines its efficacy in terms of participation, longevity, and ecosystem services. As a result, the model of governance that is selected affects the ecological efficacy of gardens. This research also seeks to determine the most effective governance approach(es) to provide models for development of community gardens in other locations.

Social outcomes of gardening depend upon and affected by the garden members' involvement and dedication (Petrovic et al., 2019). This dual relationship distinguishes community gardens from urban green spaces that are operated by city agencies (Moskell and Allred, 2013). The social outcomes of gardening are expressed by the level of gardeners' satisfaction with an assortment of outcomes. A value of an urban resource can be measured by "the function of the human activity and social network in which the resource is situated" (Foster et al., 2018, p. 1). The Diverse Economies Framework was used to understand what gardeners prioritize and value, and how they envision their community gardens in terms of their goals, barriers, and success. The Diverse Economies framework investigates non-capitalist activities of material survival people perform in a diverse social space to distributing surplus, encountering others, caring for commons, and investing for the future (Gibson-Graham et al., 2013). Self-provisioning offered by community gardening argues against "the dominant reading of a consumer- and market-driven society and challenges representations of the unilinear trajectory of capitalist development." (Gibson-Graham, 2008, p. 625). This research contributes to the diverse economies scholarship by arguing that community gardens represent 'community economies' — "spaces of decision making where we recognize and negotiate our interdependence with other humans, other species, and our environment." (Gibson-Graham et al., 2013, p. 54). To conceptualize them as community economies, it investigates whether the management of community gardens in Austin, Texas, includes the principles of 'ethical action' described by the Diverse Economies framework (Figure 2).

Community gardens create social networks that extend beyond the garden and facilitate social cohesion through shared values and behavioral norms (Kingsley and Townsend, 2006). The spatial interaction of actors with these networks, political, social, and environmental conditions influences the viability of community gardens. This study analyzes community gardens as spatial socio-environmental outcomes of organizational structures that reflect the spatially explicit dynamics of power, social and ecological processes existing in Austin, Texas. Community gardens can be viewed as 'spatial practice' from Henry Lefebvre's spatial triad as they represent the lived experiences of people. As a result, the socio-environmental outcomes of gardening vary among gardens reflecting the importance of settings in which gardens operate through the lenses of urban political ecology. This research was conducted during COVID-19 pandemic, with social distancing in place, a crucial measure for slowing the spread of COVID-19. Social distancing can negatively affect the participation, networking, and creation of social capital. It also affected the process of data collection. On the other hand, restrictions related to COVID-19 pandemic can increase people's longing for outdoor activities and nature. The following section reviews alternative food movements, community gardens as instruments of urban resilience-building, the benefits and barriers to success and governance of community gardens, urban political ecology, socio-ecological systems, and diverse-economies frameworks.

Alternative Food Networks as Responses to Food Insecurity and Social Exclusion

Food Insecurity and Social Exclusion

Food quality and food availability directly contribute to quality of life, which makes a food system one of the main characteristics of a community. More scholars and city planners are engaging with food insecurity and social exclusion which run counter to quality of life (Wrigley et al., 2003). Food insecurity raises questions about food insufficiency, particularly healthy food, and increases a feeling of social exclusion among marginalized groups. It also affects mental health by raising anxiety and stress related to food acquisition, specifically among poorer populations (Kneafsey et al., 2013). Social exclusion "involves the lack of or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas" (Levitas et al., 2007, p. 9). A food system is "the set of activities and relationships that interact to determine what, how much, by what method, and for whom food is produced and distributed" (OECD, 1981, cited in Whatmore 1996, 37). Supermarkets and grocery stores are considered "conventional" food systems (Bodor et al., 2008; Dunkley et al., 2004). The neighborhoods without access to supermarkets and grocery stores are deemed "food insecure." Access to food depends on multiple factors: distances to supermarkets, race, income, perceptions of food environments, food prices, access to refrigeration and cooking devices, and the availability of transportation (Calvez et al., 2016, Bedore, 2010).

The accumulation of opportunities within a neighborhood food-environment is more important than distance to the nearest store in explaining differences in individuals' dietary intakes (LeDoux, et al., 2014). Social geographers have increased their attention to food justice movements, food sovereignty, and 'community food security' (Del Casino, 2015). Heynen, Kurtz, and Trauger (2012) argue that the creation of spaces "for community interaction around the preparing, preserving, and consuming of food" contributes to food sovereignty. This idea has become a focus for research by an increasing number of geographers. Calvez et al. (2016) describes a foodscape as a landscape that considers the three sets of factors: the built environment, the socio-cultural, political, and economic processes at play, and the power relations at work.

The emergence of food spaces (such as, community gardens, farmers' markets, foraging) involves several stakeholders – organizations, institutions, community members – who create networks that operate through various mechanisms of coordination and control (MacDonald, 2013). Food practices and the food environment create social structures and relationships, where food is a tool of place-identity and place-making and, therefore, food spaces (Del Casino, 2015).

The role of institutions in the shaping of foodscapes has been examined by analyzing power relations in food environments (Miewald and McCann, 2014; Cummins and Macintyre, 2002). Formal and informal organizations contribute to individual food security by influencing food availability and accessibility, and each person's perceptions of the food environment (e.g., through advertising). This impacts consumption behaviors and diets (Caspi et al., 2012). Urban food systems depend on multi-scale relationships between the community and power holders, society and nature, and individuals and the neighborhood. In 2009, the International Planning Committee emphasized humans' right and responsibility to participate in decision-making regarding food production and distribution (Jarosz, 2014). The Rome Declaration on World Food Security opened a discourse (which adopted Marxist views of political economy and political ecology, analyzing power relations and the impacts of the capitalist development) on food-related issues around food sovereignty, a precondition for genuine food security (Jarosz, 2014). Food sovereignty is premised on democratic control of land, water, and environmentally sustainable food systems (Holt-Giménez, 2011). The role of the government in food sovereignty discourse is as a power institution that reshapes food systems in ways that protect rights to food (Jarosz, 2014).

The 2009 report of the International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD) prioritized small-scale sustainable agriculture over conventional, industrialized agriculture. Community gardens, for example, as self-sustaining agricultural practices represent a way to simultaneously achieve food sovereignty and food security. But before digging further into the notion of community gardens, a deeper discussion of the alternative food movement is needed.

Alternative Food Movements

Place-based projects offer people opportunities to develop local alternatives to industrial, corporate foods (Hassanein, 2003). Local food movements seek to connect people to the land and to food through urban gardening, farmers' markets, youth gardening, new immigrant farming projects, and community-supported agriculture (Lowery et al., 2016). The research on local food focuses on the issues of food quality, healthy diets, just food systems, environmentally sustainable food production, economic support for local small farmers, and questions of food inequality and social exclusion (Grey, 2000; Bedore, 2010; Kloppenburg et al., 2000; La Trobe and Acott, 2000; Jarosz, 2008, Levitas et al., 2007). Local food movements cover a spectrum of issues: health, community and economic development, social justice and food security, land preservation, environmental conservation, and urban greening (Kremer and DeLiberty, 2011). A definition of 'local' is often based on administrative boundaries (Kremer and DeLiberty, 2011) or a 400-mile radius created for the USDA's rural loan programs (Clancy and Ruhf, 2010). An alternative food network (AFN) regards "the spatial proximity between farmers and consumers, the existence of retail venues such as farmers markets, community supported agriculture (CSA) and a commitment to sustainable food production and consumption" (Jarosz, 2008, p.231). Research on AFNs began in the late 1990s (Maye and Kirwan, 2010). AFNs represent a complex structure that includes multiple processes, actors, and the relationships between them, both place-specific and universal. AFNs reveal place-connected social and environmental values about food production, distribution and consumption and aim to overcome food disparities and to promote just food systems, including equal and adequate access to healthy food.

Jarosz (2008) discusses four characteristics of AFNs:

1. Reduced food miles (the distance between producers and consumers)

Direct communication between farmer and consumer, avoiding middlemen, helps to establish trust and cooperation (Carolan, 2006; Sage, 2003), and increases consumers' awareness of the quality of the food they purchase and the environmental and social conditions of its production (Jarosz, 2008).

2. Small-sized farms applying organic farming methods

3. Community supported agriculture, food cooperatives, farmers markets, and local food-to-school programs

These food venues are the opposite of supermarket chains because they rely on local food production instead of the importation of groceries (Hendrickson and Heffernan, 2002). The problem with AFN venues rests in their seasonal nature; when they are not in season, the demand reverts to the supermarkets.

4. Sustainable food production, distribution, and consumption

Research on local food movements connects the localization of food systems to the promotion of environmental sustainability and social justice (DuPuis and Goodman, 2005).

AFNs often develop due to urbanization and rural restructuring. Rural restructuring involves the development of small-scale farms destined to provide seasonal foods for urban areas through farmers markets and community-supported agriculture (Jarosz, 2008). Urbanization increases the demand for easy-accessible food and may contribute to the development of AFNs (Jarosz, 2008). These processes have lead to the creation of governmental institutions and NGOs that support local-food movements. The role of these institutions is to ensure access to locally grown food particularly for vulnerable populations, such as senior citizens and the poor (Jarosz, 2008). Complex social relations, including social connectivity and reciprocity, affect AFNs (Granovetter 1985).

Alternative food movements (AFMs) include sustainable agriculture, local foods, fair trade, direct trade, slow food, etc. Urban agriculture is “the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities" (Kaufman and Bailkey, 2000, p. 3). Community-led horticultural initiatives, such community gardens, serve to improve the social–environmental stresses of urban living by providing interactions with nature, creating sense of place and community, increasing air quality and food security, food quality and freshness (Twiss et al., 2003; Corrigan, 2011). Urban agriculture produces social capital for the citizens, creating solidarity, relationships of reciprocity, and networks of self-sufficiency, which stresses the use value of urban space in the first place (Purcell et al., 2014). AFMs can create market mechanisms, like direct trade, that exclude intermediaries (Agyeman et al., 2014). These mechanisms, however, are still neoliberal in that they promote market-based rather than state-based solutions to social problems (McEntee and Naumova 2012, p.248).

One of the deep challenges for AFNs is gender and racial inequality. Research has demonstrated that "race and class play a central role in organizing the production, distribution, and consumption of food" (Alkon and Agyeman 2011, p.4). Slocum (2006) emphasizes white privilege in food systems and how ethnic minorities disproportionately experience food insecurity. Sometimes other racial groups, like Spanish-speaking immigrants in California, Texas, and Illinois, for instance, are more likely to experience food insecurity than White Americans (Kasper et al., 2000). Sustainable AFNs, therefore, expose power imbalances within all ethnic groups and address the differences among groups of color (Slocum and Saldanha, 2013). Local food movements must benefit all groups in a community regardless of race, gender, age, and class. The roles of formal organizations are crucial to achieving equality. One example NGO is the Community Food Security Coalition, which facilitates the building of food security and food selfreliance across the U.S. and promotes food systems based on principles of justice, democracy, and sustainability (Slocum, 2006). Donations to local food banks made by local farmers and urban gardeners are another way to address food insecurity (Jarosz, 2008). AFNs also provide positive environmental outcomes, like biodiversity and decreased water and energy demands. Local food movements are an instrument of urban socio-ecological resilience building (Colding and Barthel, 2013). Urban ecological resilience describes the impacts of urban development on natural ecosystems, which includes fragmentation of natural habitats, disruption of hydrological systems, contamination, environmental degradation, and replacement of natural land covers. Urban social resilience building includes various social aspects, such as food insecurity and social exclusion. Next section discusses community gardens and their contribution to urban socio-ecological resilience building, including ecological services, creation of sense of place and construction of the knowledge about social entrepreneurship.

Community Gardens for Urban Resilience Building

Socio-environmental Benefits of Community Gardens

Glover defines a community garden as "an organized, grassroots initiative whereby a section of land is used to produce food or flowers or both in an urban environment for the personal use or collective benefit of its members" (Glover et al. 2005, p. 79). Community gardening research has focused on sustainability as community gardens integrate their components with an emphasis on environmental and social dimensions.

Community gardens are usually vacant lots in urban areas with public or private land ownership that community members use for urban agriculture (Schukoske, 2000). There is a positive correlation between the number of community gardens and the availability of vacant lots (Schukoske, 2000). In the U.S., community gardens often amount to short-term use of vacant land awaiting construction (Colding and Barthel, 2013). Community gardening often involves physical transformation of land, which then promotes community-identity formation and the production of place (Milbourne, 2012). Other definitions of community gardens include open spaces used for food or flower cultivation by members of a community (Holland, 2004; Pudup, 2008). Many researchers have identified access to fresh food, community-building, and social inclusion as the primary motivations for those who become involved in community gardens (Bodel and Anda, 1996; Kurtz, 2001; Turner, 2011; Hanna and Oh, 2000; Baker, 2004). In the United States, community gardens are places for social interaction and reconnection with nature (Hanna and Oh, 2000). They are also important for alternative food production in opposition to agribusiness. Community gardens can help overcome the problem of food insecurity while providing people with safe and clean produce (Ferris et al., 2001). Other social advantages of community gardens include improved mental and physical health, reduced crime or increased safety, and cultural exchange (Guitart et al., 2012; Kurtz, 2001; Mundel and Chapman, 2010). Many scholars argue that urban gardens improve the environmental and social quality of city space by enabling socialization and environmental education (Certoma et al., 2015; Waliczekz et al., 1996; Wekerle et al., 2009). Participation in urban agriculture projects bring people together to work alongside each other, to communicate, to share seeds, to share harvests, to share recipes, to share knowledge, to use common resources (e.g., water) and to perform duties like composting and recycling. Gardening may produce a sense of accomplishment and self-actualization (Agustina et al., 2012). There are other non-gardening activities within community gardens that bring people together as well: picnics, festivals, cookouts, and other cultural or spiritual activities (Guitart et. al, 2012). Barraclough (2009) studied community gardens in terms of cultural heritage. The economic benefits of community gardens include saving money on food consumption and changing the value of adjacent properties (Guitart et al., 2012).

Scholars have also studied urban community gardening in terms of Lefebvre's "right to the city," which is the struggle for a democratic city, where citizens can produce and directly manage urban space according to their needs (Purcell et al., 2014). Lefebvre suggests that this right is neither achieved by the citizens nor given to them by the state. Instead, it is a condition that people must realize and pursue. It parallels Marxism's idea that people should govern themselves and manage their affairs themselves (Purcell et al., 2014). According to Lefebvre, urban spaces are constructed by a limited number of actors (an elite) who impose their (neoliberal) values on others. Scholars view community gardening as a desire to achieve self-governance (Lefebvre, 2003b [1970]). When people participate in collective action offered through a community garden, they exercise their right to produce and manage their city.

Community gardens create social networks through the numerous activities associated with gardening: planting, cleaning, composting, recycling, decision-making, fundraising, sharing produce, cultural events, etc. (Glover 2004). These social networks often extend beyond the garden and facilitate social cohesion through shared values and behavioral norms (Kingsley and Townsend, 2006). As a result, gardens create social capital through the production of natural capital (Howard, 2004). Putnam (1995, p. 67) defines social capital as the “features of social organizations, such as networks, norms, and trust, that facilitate actions of cooperation for mutual benefit.” Taylor et al. (2014) state that urban gardens provide women with a sense of self-efficacy. White (2011) discusses how African American women’s participation in community gardening in Detroit is viewed as a form of social activism, “one where their energies not only feed their families and their communities healthy food, but also feed their need to be the change agent in their community” (p. 24). A community garden helps to increase a community’s “resistance to marginalization and dominant narratives of urban development” (Taylor et al., 2014, p.289), which include the structures of land use and urban design (Baker, 2004).

Community gardens integrate across scales: at both collective and individual levels and the array of scales of action and meaning (Milbourne, 2012). Milbourne (2012) employed community gardens in disadvantaged neighborhoods to investigate socio-environmental (in)justice through local and day-to-day scales. Nature, society, culture, and power relations come together in a space of a community garden. Researchers emphasize the roles of everyday spaces in environmental justice (Whitehead, 2009). Community gardens are products of human experience, collective actions, everyday practices, and formations of identities (Bhatti and Church 2001, Milbourne, 2012).

Schmeizkopf argues that community gardens are “part of the public domain and are the sites of many functions conventionally equated with the private sphere” (Schmeizkopf 1995, p. 379). He shows how community gardening contributes to the construction of sociality, public participation, sustainability, and justice. As environmental projects, they produce “lived urban spaces in social and ecological terms” that embed the needs and values of their inhabitants (Milbourne, 2012, p. 954).

Certoma et al. (2015) discuss urban gardens as political commitments expressed through practical arrangements of things and beings in cities’ spaces (Certoma et al., 2015). They discern the aims of the participants of urban gardens (taking power, contesting power, abolishing powers, etc.) and the means (peaceful protest, direct action, guerrilla tactics, up-risings, riots, cultural opposition, etc.) as heterogeneous which creates challenges (Certoma et al., 2015). Community gardening involves material transformation of public space through people interacting with non-human agents (Certomà, 2011), creating new physical, material, and aesthetic settings. By controlling and managing biophysical systems, citizens exercise their ‘right to the city’ (Harvey, 2008). Others argue that urban gardening projects aim to establish the “right to space” (Schmelzkopf, 2002) and social justice (Reynolds, 2014).

Corcoran and Kettle (2015) discuss the social capital generated by community gardening –solidarity, mutuality, and trust. They describe urban gardening as a common denominator that mitigates the disparities between gardeners of different backgrounds. In the United States, community gardening is often seen as “a socialistic enterprise reflecting communitarian values” (Guitart et al., 2012, p 369). On the other hand, some scholars see urban gardening as a neoliberal practice that leads to gentrification and social inequality (Pudup, 2008; Johnston, 2007).

Colding (2007) stresses the values of domestic and communal gardens in urban ecological resilience. Socio-ecological resilience is “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity" (Folke et al., 2010). Urban greening projects can increase resilience to disaster if they "integrate natural, human, social, financial, and physical capital in cities, and…encompass diversity, self-organization, and adaptive learning and management leading to positive feedback loops" (Tidball and Krasny, 2007, p. 151). Colding and Barthel (2013) argue that community gardens contribute to resilience-building by creating a sense of place, promoting democratic values, and constructing knowledge about social entrepreneurship. Colding (2007) showed that ecological land-use complementarity in urban green areas provides habitat for diverse species and promotes ecological processes. Ecosystems provide numerous services: provisioning (of natural resources, for instance), regulating (floods and climate), cultural provision (through things like recreation and entertainment), and supporting systems (like nutrient cycling and soil formation) (Dennis and James, 2016). Ecological economists define ecosystem services as "components of nature, directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf, 2007, p. 619). Researchers talk about ecosystem services as "those components of the natural environment that provide a long-term stream of benefits to individual people or to the society as a whole" (Liu et al.,2010).

Depietri et al. (2016) argues that, instead of being pure "natural capital," ecosystem services are "socially produced," as they are intertwined with social, economic, and political processes (Ernstson, 2013). Ecosystem services result from human-environmental interactions, as people transform nature and are also affected by the changes in natural systems (Norgaard, 1994). Therefore, social-ecological processes embody and reflect social factors (Swyngedouw and Heynen, 2003) as their production involves human efforts, technology, and institutional interventions in nature (Depietri et al., 2016).One of the environmental outcomes of community gardens that is discussed in the literature is the enhancement of biodiversity (Heynen et al., 2006; Buckingham, 2005). Studies have emphasized the importance of small-sized green spaces in cities to promote biodiversity and habitat restoration (Smith et al., 2006; Davies et al., 2009; Cameron et al., 2012). Many studies have emphasized the importance of small urban green spaces for biodiversity (Smith et al., 2006; Davies et al., 2009; Cameron et al., 2012). Dennis and James (2016) suggested that increased community participation in urban gardens correlates positively with biodiversity (environmental benefits) and also leads to increased food provision (social benefits). They further suggest that small green spaces more easily generate high levels of participation (Dennis and James, 2016). Holland (2004) connects the use of underused spaces for community food production to regenerating vegetation to contribute to sustainability. Community gardens also provide environmental education and promote environmentally responsible behaviors (Colding and Barthel, 2013; Lyson and Raymer, 2000).

Other environmental benefits from community gardens as green spaces include microclimate regulation, filtration of atmospheric particulates, rainwater retention, and noise attenuation (Haase, 2015; Zinia et al., 2018, Bolund and Hunhammar, 1999). Hansen and Pauleit (2014) detail urban green space mitigation of the consequences of extreme heat events. Vegetation can lower ambient air temperatures through evapotranspiration and shading (Zhang et al., 2014). Gill et al. (2007) argues that an increase in urban green infrastructure by 10 percent would decrease the temperature in Manchester, UK, by 4 ◦C over the next 80 years. The effect on urban temperatures depends on the type of plants (Cameron et al., 2012), with an urban tree providing almost 950 MJ cooling per day (Huang et al., 1990). The role of the urban green spaces in mitigating air pollution is described as uncertain (Pataki et al., 2011). Plants and trees associated with community gardens can remove pollution from the air (Cameron et al., 2012), and some studies suggest that air filtration is one of the main benefits of urban vegetation (Byrne and Sipe, 2010). Some plants, however, can emit biogenic volatile organic compounds, contributing to photochemical smog in cities (Niinemets and Peñuelas, 2008; Peñuelas and Staudt, 2010).

Limitations or barriers to the success of community gardens described in the literature have social, economic, cultural, political, and environmental roots. They include: obtaining long-term land tenure that is supported by policy and planning (Lawson, 2004); ongoing urban development, creating uncertainty among gardeners regarding land tenure and the futures of their gardens (Schmelzkopf, 2002); soil contamination (Wakefield et al., 2007); access to water (Wakefield et al., 2007); lack of available facilities, such as restrooms (Kingsley et al.,2009); other resources like soils, compost, fertilizers, and seeds are in continuous demand (Cohen and Reynolds, 2015); funding; the time commitment (Kingsley et al., 2009); lack of interest and participation (Drake and Lawson, 2015a); short leasing period on land (Guitart et al., 2012); absence of technical skills (Cohen and Reynolds, 2015); distance to a garden site and modes of transportation (Kingsley et al., 2009; Broad, 2016); environmental education (Broad, 2016); conflict of interests when a large network of stakeholders is involved (Diaz et al., 2018); and social tensions, low levels of trust, and other conflicts between the gardeners.

Community Gardens and Urban Ecology

The amount of green space in a city affects its ecological health. Carbon uptake by garden plants and soil depends on the vegetation types, the length of the growing season, and the garden's design and management (Cameron et al., 2012). Carbon sequestration involves capture and storage of atmospheric carbon dioxide (USGS, 2018). Many researchers discuss the process of carbon sequestration in the discourse of global warming (Tripathi et al., 2010; Kuittinen et al., 2016; Heimann, 1989). Carbon dioxide is captured by plants through photosynthesis and becomes a material for roots, leaves, trunks (NASA, 2011). Furthermore, vegetation transports carbon to heterotrophs and storage pools in the soil (Field et al., 1995; Kuittinen at al., 2016). In return, plants release energy and oxygen back to the atmosphere.

The difference between absorbed and released carbon dioxide defines plants' net primary productivity (NPP), a measure of carbon sequestration (National Aeronautics and Space Administration, 2000). It is the carbon that stays in the ecosystem that provides for the functioning of its components (Chapin III et al., 2007). NPP depends on the numerous natural and anthropogenic factors: soil type, air temperature, humidity, and specific plant characteristics (Field et al., 1995; Ito et al., 2004). Anthropogenic factors can affect NPP as well. Those that diminish NPP are urbanization, overgrazing, water diversion, air pollution, and others (Field et al., 1995). The plants chosen for gardening, fertilizers, irrigation practices, and introduction of nonnative vegetation can increase NPP (Chameides et al., 1994; Vitousek and Walker, 1989; Munson et al., 2014). The relationship between human activities shows that community development and environmental management are intertwined (Khan, 1999) and sustainable development depends on active community engagement (Stocker and Barnett, 1998).

Many researchers have attempted to estimate carbon sequestration using remote sensing analysis (Tripathi et al., 2010; MacDicken, 1997; Hunt et al., 2004; Field et al., 1995; Tucker, 1979; Christensen et al., 1993). The amount of absorbed carbon dioxide depends on a plants' biomass, which can be measured using a vegetation index like the normalized difference vegetation index (NDVI) (Christensen et al., 1993; Gitelson et al., 2014). NDVI describes the relative density of vegetation for each picture element (pixel) in a satellite image (NASA, 2000).

Another aspect of NPP is photosynthetically active radiation (PAR), which represents the amount of light available for photosynthesis, and it depends on the position of the sun during the day, latitude, season, cloud coverage, built environment, and other factors, such as air pollution (Environmental Monitor, 2010). The part of the solar spectrum used in photosynthesis extends from 400 to 700 nanometer wavelengths (Qin et al., 2011) as plants absorb light from the visible range and reflect near infrared wavelengths (700-1300 nm). PAR values can be measured with instruments or can be calculated from remotely sensed data (Ross and Sulev, 2000; Pinker and Laszlo, 1992; Zheng et al., 2008). PAR is expressed as either photosynthetic photon flux density (μmol photons/m^2/s or as photosynthetic radiant flux density (W/m^2) (Mõttus et al., 2012).

Carbon sequestration models typically depend on two factors: the amount of solar radiation absorbed by vegetation and the efficiency of carbon fixation or light use efficiency (LUE) (Sims et al., 2006; Monteith, 1972). These models suggest a close relationship between the fraction of absorbed photosynthetically active radiation (fAPAR) and the normalized difference vegetation index (NDVI) (Choudhury, 1987; Goward and Huemmrich, 1992; Sellers, 1985; Sims et al., 2006). fAPAR represents the portion of the light spectrum used by plants for photosynthesis. It is expressed as a ratio, Absorbed PAR:Total PAR (Mottus et al., 2012). Absorbed photosynthetically active radiation (APAR) is the amount of radiation absorbed by the vegetation, and it also can be measured from remotely sensed data (Hunt et al., 2004).

NDVI is the most common vegetation index used to measure fAPAR (Propastin et al., 2012, Goward and Huemmrich, 1992). Ruimy et al. (1994) defines the relationship between NDVI and fAPAR as: fAPAR = 1.25NDVI – 0.10. Sims et al. (2006) uses a similar correlation: fAPAR = 1.24NDVI – 0.168. Tripathi et al. (2010) suggests the value of fAPAR equal to NDVI. Other studies calculated fPAR as a function of the leaf area index (LAI) (Ruimy et al., 1999). The first algorithm for NPP calculation using the APAR and LUE parameters was proposed by Monteith in 1972 (Propastin et al., 2012) and was applied in the Carnegie–Ames–Stanford approach (CASA) to analyze global NPP (Potter et al., 1993). While some of the CASA variables (such as PAR and LUE) are biophysical phenomena and depend on the specific characteristics of a geographical location (climate and latitude) and the position of the sun, others (such as NDVI) partially depend on human activity: garden members decide what type of plants and how many of them to grow, as well as how they participate in the plant growth process. A garden's biomass is related to the time and effort invested by the gardeners.

Research on community gardens has mainly focused on low-income areas with various levels of ethnic diversity in industrial cities of the U.S. (Guitart et. al., 2012). Most analyzed community gardens from the gardeners' perspectives; with few studies focused on institutions and agencies who directly or indirectly manage community gardens (Guitart et. al., 2012). It is important to analyze who owns, manages, and operates community gardens because they influence their outcomes.

Community Garden Governance

Community gardens involve numerous stakeholders that may represent schools, hospitals, religious institutions, local communities and members, and marginalized groups like youth, the elderly, diverse racial and ethnic groups (Pudup, 2008; Teig et al., 2009; Saldivar-Tanaka and Krasny, 2004). Governments and NGOs may also be involved as they advocate, educate, plan, and negotiate for community spaces (Eizenberg, 2012). More stakeholders mean that decisions are more fully informed and that there are more options for policy making (Colding et al., 2003). With multiple stakeholders, the right to manage does not necessarily rest on ownership. Colding and Barthel (2013) argue that diversity in ownership may lead to the combination of formal and informal environmental management strategies.

Management practices, institutional rules, and biophysical garden structure result in ecosystem services and the combination determines their strength (Andersson et al. 2007). These practices, methods, and techniques are stored in and transported by the social-ecological memory, a part of collective memory (Barthel et al., 2010); an important asset of ecological resilience (Folke et al., 2003). Social-ecological memory related to community gardens also includes the collection of ecological information, its observation, interpretation, the creation of meanings, and analysis (Barthel et al., 2010). Collective memory stores experiences of living pasts and determines behavioral patterns of societies (Middleton and Edwards, 1990; Coser, 1992; Gongaware, 2003; Barthel et al., 2010) and it consists of individual memories shared via social interactions through language, symbols, events, and cultural contexts (Barthel et al., 2010). Barthel et al. (2010) analyzed how members of allotment gardens retain knowledge, experience, and practice of ecosystem management. Reification materializes interpersonal relations and relationships to ecosystems through objects, phrases (Nazarea, 2006), institutions, or the rules in use (regulations, informal norms, and property rights) (Ostrom, 1990; North, 1994). Reification depends on the participation of members of community gardens in gardening activities as well as collective meetings, rituals, and other social gatherings (Barthel et al., 2010). In community gardens, participation creates physical objects – the sizes and forms of individual plots, different functioning zones, and their distribution within the garden – which influences gardening practices and communications and creates social-ecological memory. Spatiality also directly affects ecological processes like carbon sequestration (Barthel et al., 2010) since garden members choose the mixture and physiological characteristics of plants they desire. External forces, like governmental agencies and non-profit organizations that facilitate community gardening, are also involved in the formation of social-ecological memory.

Many urban green spaces have become privatized in neoliberal contexts and this creates conflicts between capital's interests and citizens' desires to access green spaces (Ghose et al., 2014). Community gardens contain embedded capital and the participants, therefore, can be influenced and even evicted by the businesses or the local governments

(Quastel, 2009; Ghose et al., 2014; Egerer et al., 2018). Ghose et al. (2014) showed that community gardens depend on the social networks to survive, function, and overcome barriers. Gardeners create ties with non-profit organizations, government agencies, and businesses to obtain materials, resolve land-use conflicts, or acquire other resources, like information and advocacy support (Ghose et al., 2014; Schmelzkopf, 2002; Staeheli et al., 2002; Baker, 2004). Zinia et al. (2018) suggests that the success of urban green spaces depends on the cumulative efforts of the public and government through awareness campaigns and law enforcement.

The tension between individual interests and a community's interests can lead to collective-action problems (Taylor, 1990). But they can be resolved by implementing co-management. Co-management is driven by common-interest benefits and ecosystem services, because it integrates the positive qualities of all strategies, improves communication between participants, and results in adequate rules and norms (Andersson et al., 2007; Ostrom, 2005). Co-management also benefits community members by involving them in decision-making, and this develops positive social capital (Rydin and Pennington, 2000). Therefore, when stakeholders share common interests and values, communicate with each other, and operate on the large scale, they can produce more adequate governance rules and norms with less need to develop monitoring and sanctioning mechanisms (Ostrom, 2005). Many studies have provided examples cooperation when it was not rational to do (McCay and Acheson, 1987; Berkes, 1989; Ostrom, 1990, 1999a, 2000; Baland and Platteau, 1996; Anderson and Simmons, 1993). Others have described co-management techniques to share power between community members and government agencies (Pinkerton and Weinstein, 1995). Participation in the management of urban gardens provides community members with a feeling of control over "their" urban space, increasing the feeling of power among marginalized or disadvantaged groups (Eizenberg, 2012). Consequently, community gardens contribute to the development of more politically powerful urbanites. Ostrom suggests that polycentric governance facilitates "public entrepreneurship" – public participation in local co-production of goods and services (Foster et al. 2018). Polycentric governance involves multiple governing units or authorities at different scales that have high degrees of independence in rulemaking (Ostrom, 2010b). Nagendra and Ostrom (2014) argues that communication between communities and the government can positively affect such outcomes, as ecological conditions, and collective action. Polycentric governance integrates self-organization and collaboration with governmental, scientific, and other institutions (Baud and Dhanalakshmi, 2007). On the other hand, the collective-choice approach can constrain decision-making (Ostrom, 2011).

The models of governance of community gardens vary from collaborative management by a group of gardeners to management by a third party like an NGO or a government agency (Taylor et al., 2014). Collective, place-based decision-making is beneficial for social capital and community building (Gottlieb and Fisher, 1996), a model that promotes citizens' rights to the city (Smith and Kurtz, 2003; Harvey, 2008).

The two main community-garden governance structures are the bottom-up and top-down models (Nettle, 2014). Top-down governance typically includes a local government and non-governmental professionals, while bottom-up governance involves community members leading decision making (McGlone et al., 1999). In practice, governance often blends these models (Nettle, 2014); government agencies and gardeners share the power. McGlone et al. (1999) distinguished five types of governance of community projects (including community gardens): “top-down” – projects managed and run by professionals, “top-down” – projects managed by professionals but run by paid workers/volunteers, “bottom-up” – projects managed and run by local communities with the help of paid workers and professionals, “bottom-up” – projects managed and run by local communities with informal professional support, and “bottom-up” – projects managed and run by local communities. Fox-Kämper et al. (2018) suggested a sixth type: “bottom-up” – projects with political and/or administrative support for funding, land tenure, and advising.

There have been debates regarding the most effective form of governance for community gardens (Eizenberg, 2012; D'Abundo and Carden, 2008; Fox-Kämper et al., 2018; Austin et al., 2006; Palamar, 2010; Stocker and Barnett, 1998; Petrovic et al., 2019). When decision-making is run entirely by the government and external professionals, gardeners feel estranged from their gardens (Eizenberg, 2012). Governmental and non-profit organizations can impose their own interests and goals on the gardens and, therefore, the gardeners (Ghose et al., 2014). On the other hand, professional expertise and governmental support provide stability and longevity (Palamar, 2010; Follmann and Viehoff, 2015; Austin et al., 2006; Ghose et al., 2014). Studies have suggested that the success of community gardens depends on the levels of gardeners’ participation, and these are connected to the levels of power they hold in management and decision-making (Howe and Wheeler, 1999; Stocker and Barnett, 1998; D'Abundo and Carden, 2008). Thus, an ability to participate in decision-making processes is very important to gardeners during both the planning and design phase and the management and development phase (Petrovic et al., 2019; Fox-Kämper et al., 2018). However, equal distribution of power among gardeners can also create conflicts between individuals' interests and motivations (Follmann and Viehoff, 2015). Some argue that successful gardens apply "bottom-down" models of governance where certain groups of citizens take leadership (Ghose et al., 2014). Such internal structures of governance can vary from dictatorial to anarchistic (Lawson, 2009).

The lifespans of community gardens depend on the durations of land leases. The primary contribution of NGOs in support of urban agriculture and gardening is in securing land for community gardens (Janson Waddick, 2000). However, when NGOs are involved in managing community gardens, there are fewer options for the embedding of meanings into the gardens (Blomley, 2004). This situation contradicts the idea of autonomous community space, which emphasizes the production of multiple meanings of space based on the needs and cultures of different communities (Eizenberg, 2012). A government agency or participating planners should recognize the importance of community-gardening initiatives for urban social–ecological networks (Dennis and James, 2016). The rules determine cooperation and decision-making, and guide participation and behavior (Barthel et al., 2010).

Decentralized management is an adaptive response to environmental degradation (Gunderson and Holling, 2002). Adaptive management approaches consider uncertainty and encourage innovation (Gunderson and Holling, 2002). The Trust for Public Land is an example of an NGO that promotes a decentralized management model and gives most of the urban-gardening rights to the gardeners (Linn, 1999, Eizenberg, 2012). The Trust for Public Land transfers legal ownership over to the residents, and encourages community participation (Eizenberg, 2012). But community members must have the necessary skills and knowledge to successfully manage the gardens.

To summarize, factors that enable the functioning of community gardens include secure land tenure and funding, community engagement, dedication, and motivation, advise from professionals, networks, and organizational support (Fox-Kämper et al., 2018). Fox-Kämper et al. (2018) suggests that 'bottom-up' governance with political or administrative support benefits both gardeners and municipalities: "gardeners may receive support to overcome hurdles while planning, implementing, or managing a garden. […] municipalities that support community gardens may benefit from an effective model for strengthening neighborhoods and improving social cohesion" (p.66). Many have advocated for a combination of gardeners' autonomy and support from environmental-stewardship organizations (Roman et al., 2015; Petrovic et al., 2019). Some studies have found some community garden members who indicate that not having professional coordination is a barrier to success (Fox-Kämper et al., 2018). Holland (2004) describes one of the management styles of community gardens that involves a defined active committee, who considers both the gardeners' opinions and external expertise when making the decisions. The influence of the external stakeholders should not conflict with the knowledge and goals of a garden's members.

Collective action associated with community gardens brings together people with different backgrounds. If they do not manage to successfully cooperate, the collective can produce social costs that include social tensions, low levels of trust, and related conflicts. Diaz et al. (2018) argued that a conflict of interests occurs when an extensive network of supporting stakeholders pursues divergent goals. Sometimes community gardens promote social inequality by excluding people based on race or class (Carolan and Hale, 2016). Some have argued that the longer a garden exists, the harder it is for newcomers to join because members establish tight and strong social ties that prevent the introduction of new ties.

Studies have concluded that “successful” community gardens involve collaboration between different organizations, strong social capital, and high levels of community engagement (Diaz et al., 2018; Fox-Kämper et al., 2018; Howe and Wheeler, 1999; Stocker and Barnett, 1998). Social capital includes sense of place, social networks, trust, and reciprocity, and is beneficial for individuals (Altschuler et al. 2004). Rydin and Pennington (2000) connect positive social capital with a community’s authority to create their own rules and norms. Many researchers suggest that community gardens are typically self-organized and initiated by community members (Colding and Barthel, 2013). However, community gardens can be successful through collaboration among multiple stakeholders communicating and cooperating towards a common goal (Hesse et al., 2015). Participation levels are higher when people share common interests and enjoy collective efforts (Colding and Barthel, 2013). Community gardens’ managers need to consider the cultural and social characteristics of the community to promote participation (Holland, 2004). It is more challenging to increase involvement in gardens that serve a specific purpose or are difficult to access (Holland, 2004). Scholars generally advocate for strong and organized management styles because they can resolve issues easier and promotes social support, connections, and networking (Kingsley and Townsend, 2006).

Economic incentives provided by municipalities that facilitate community gardens and other urban agriculture projects are also important. For instance, reducing fees for water and garbage services is beneficial (Horst et al., 2017). Philadelphia exempts community gardens from stormwater fees, for example (Jaramillo, 2016). The size of the garden is another factor associated with the successful gardening projects. Environmental education is more likely to occur in smaller, enclosed community gardens that favor communication between gardeners (Krasny, 2009). Rule monitoring, enforcement, and sanctioning are also more effective within smaller community gardens (Barthel et al., 2010a).

A value of a resource can be measured by "the function of the human activity and social network in which the resource is situated" (Foster et al. 2018, p. 1). A garden holds a value when it provides people with what they want, considering that they can access it and use it. The Diverse Economies Framework is a framework that can help to understand why communities have certain values (Carolan and Hale, 2016). Community values are not objectively given or imposed on the community but are built and shaped through activities and communication. It is necessary to identify the factors that contribute to the success of a community garden in a specific geographical context to eventually create a universal model. Heynen et al. (2006) suggested the use of political ecology as a framework to analyze the impacts of social, political, and economic factors on the environmental impacts of urban green spaces. The following section describes theoretical frameworks utilized by this study: urban political ecology (UPE), Ostrom's Socio-Ecological Systems (SES) and the Diverse Economies frameworks (Figure 1).

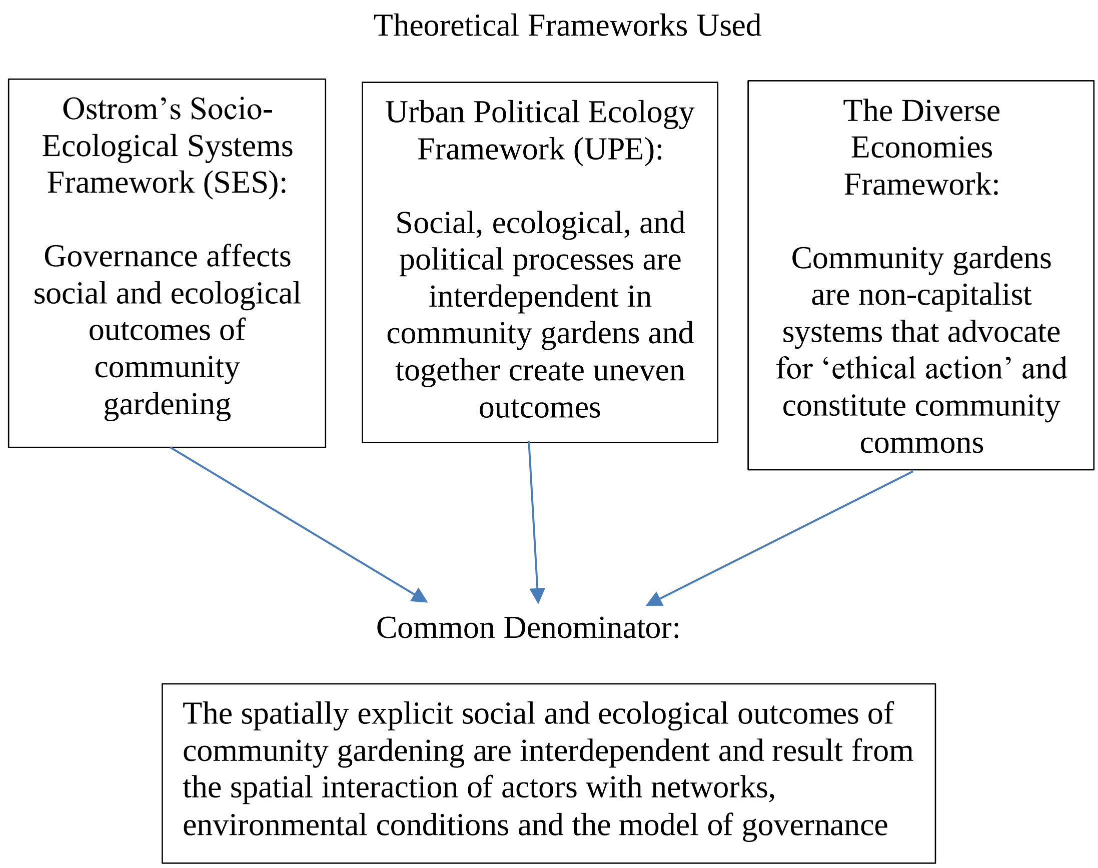


Figure 1: Summary of theoretical frameworks used in this research.

CHAPTER II

THEORETICAL BACKGROUND

Urban Political Ecology Theory

Early political ecology searched for the links between capitalism and socio-ecological processes, which evolved into research about institutions and bureaucracy and their determinations of the environmental order (Rademacher, 2015). From the beginning, political ecology was engaged with degradation, sustainability, capitalism, and human transformation of nature. In the 1990s, there were two main themes of political ecology (Rademacher, 2015). First, researchers considered natural resources as an instrument through which social power dynamics are expressed, and they analyzed political, economic, and institutional meanings of natural resources. Second, the idea of the separation of nature-society was challenged, and scholars analyzed how people produce spaces and cultural meanings.

Robbins (2012) discussed political ecology's emergence and evolution as a field that analyzes social and ecological issues through money, influence, and control. Political ecology is a critical response to environmental determinism. According to Robbins (2012), there are five major themes in political ecology: the degradation and marginalization thesis – linking environmental degradation and other changes in environmental systems to social and political marginalization and capital accumulation; the conservation and control thesis – focused on global and regional conservation efforts and their impacts; the environmental conflict and exclusion thesis; the environmental subjects and identity thesis – concerned with the involvement of local community in environmental management; and the political objects and actors thesis – concerned with the powers that guide relationships between the non-human and human worlds. Political ecology has evolved from an effort to understand why environmental systems change to a quest to understand how environmental changes influence social identities. The research in political ecology focuses on the causes of problems rather than the consequences. Thus, political ecology strives to understand why the costs and benefits of environmental change are distributed unequally among different groups of people, and to determine how to overcome these inequalities. There have been debates about the insufficient engagement of political ecology with ecology. Turner (2015) argued that the place-based methodological approach used by political ecology research provides specific geographical and historical contexts for studies of the connections between people and environmental conditions, and the social distribution of natural resources.

In 1996, Erik Swyngedouw suggested urban political ecology (UPE) – a theoretical framework that connects society and nature through the notion of "socionature" and moves the objectives of political ecology to urban settings. UPE recognizes that historically discussions of nature, agricultural activities, and countryside were separated from discussions of cities (Rademacher, 2015). Urban life was associated with cultural, political, and economic processes, but not with ecology. Nature stood in opposition to the city. UPE, on the other hand, includes nature in "everyday, lived social life in cities" (Rademacher, 2015, p.145). Earlier studies tended to analyze nature and society as separate realms and associated nature with good and city with bad, dirty, and cruel (Classens, 2015). Instead, UPE suggests that nature and society are co-constituted in a way that political, social, economic, cultural, and ecological factors affect nature in the city but also are affected by it (Classens, 2015). Cities, therefore, are the products of socio-nature relationships (Heynen et al., 2006; Smith, 2008), and urban environmental problems can be solved through policy changes and the redistribution of power. Urban environments are socially constructed spaces where political structure, community culture, identity, and socio-nature relationships unfold. Domene and Sauri (2007, p.288) claims that “neither socio-environmental changes nor environmental planning are socially or ecologically neutral”. Instead, society and nature are co-productive (Alkon, 2013; Moragues-Faus, 2017).

> *“It is on the terrain of the urban that [the] accelerating metabolic transformation of nature becomes most visible, both in its physical form and its socioecological consequences” (Swyngedouw and Heynen, 2003, p. 907).*

Marxist urban political ecology focuses on the “interwoven knots of *social process, material metabolism* and *spatial form* that go into the formation of contemporary urban socionatural landscapes” (Swyngedouw and Heynen, 2003, 906, emphasis in original). Keil et al. (2015) argues that nature in and around the city participates in institutional and legislative reforms concerned with urban-regional development. As a result, urban landscapes reflect the current political situation, governance systems, and socio-economic settings of the city. Society and nature are co-productive of one another, and specific place-based historical context influences this co-production. Many UPE studies, therefore, use actor-network theory as a framework, because they consider nature to be a subject, not an object (Latour, 2005; Gandy, 2004). It argues against the divisions between urban and rural, town and countryside, and nature and culture, by integrating nature into the urban settings as an equal actor. As a result, UPE provides a common language to facilitate communication between social and environmental activists (Angelo et al., 2015). So-called methodological urbanism dominates the UPE research, where the focus is on the city *per se* (Angelo et al., 2015). The object of study in UPE should not simply be the city as a physical territory with defined boundaries, but rather urban society and urbanization as a complex and multiscale process (Heynen et al., 2006; Brenner, 2013). Researchers need to analyze the processes, materials, and networks that constitute cities, and how they shape the environment. UPE is also concerned with the production of knowledge and its role in urban socionatural transformation. It investigates who has the power to produce, transform, and apply the knowledge about socionature in the city (Rademacher, 2015).

Scholars point out that in the past the discourse around sustainability in political ecology has been conducted predominately by governments and corporations in a neoliberal context, with the emphasis on carbon-reduction strategies (Moragues-Fause et al., 2015). Thus, there is a need to switch more to the analysis of different grassroots movements that involve local communities, such as alternative food networks. Recent political ecological studies typically focus on production, collective action, fieldwork as a method of empirical research, a focus on marginalized groups (low-income or people of color), and community-based environmental knowledge. For example, Heynen (2016) stresses the importance of a deeper investigation of the role of white supremacy and racialization in producing uneven urban environments.

One of the central concerns of UPE is the impact of neoliberalization on socionatural relations and local environments (Keil, 2005). Political ecology investigates who controls the decision-making process, whose voices count, and what social and political processes underpin knowledge-construction (Blomley, 2006). It investigates who has the power to produce, transform, and apply knowledge about socionature in the city. A feminist perspective on political ecology is interested in everyday practices and their connection to multiple scales: the body, the household, and the city. Passidomo (2016) uses the scale of the neighborhood as political moments that give citizens control over certain parts of the city. Some discuss community gardening as a post-environmentalist notion that directly connects people to nature daily and requires immediate solutions to environmental issues (Certoma, 2011). Post-environmentalism considers any place to be a node, connecting multiple actors, including the government, nature, material elements, and social networks. Participants of community gardens create a unique knowledge based on their direct engagement with the garden. Community gardens represent spaces of food production that belong to both the material and cultural worlds, which are not independent from each other. Community gardening implies the use of the physical environment as a form of political expression to create new physical, material, and aesthetic settings.

A large component of UPE research focuses on the nature embedded in the built urban environment and infrastructure. Many studies conclude that buildings, transportation systems, and public spaces in the city reflect a certain environmental order (Rademacher, 2015), specifically, in the Global South (Cohelo and Raman, 2013). For example, Cohelo and Raman (2013) analyzed water and land as physical infrastructures of the city that incorporate both natural and social dynamics. Some of the UPE studies are interested in the problem of governmental control of people through the control of the territory, for example, through the distribution and access to urban green spaces. Urban green spaces can express power relations in the city through design, access, organization, distribution, management, rules and regulations (Certoma, 2011). The presence of urban green spaces reflects political orientation. as the government controls people through the control of the territory (Certoma, 2011). Thus, urban green spaces do not always represent positive solutions. Sometimes they can serve as instruments of gentrification and expressions of power by privileged groups of people. Passidomo (2016) argues that they can restrict the agency and livelihoods of marginalized citizens. Many UPE studies investigate the role of urban green spaces like urban forests and parks in forming uneven American landscapes (Keil, 2003). UPE research often uses the term “ecological footprint” to describe the impacts of technology and human behavior on the environment (Wackernagel and Rees, 1996). Heynen et al. (2006) talks about the social production of urban green environments through the processes of income inequality, uneven property ownership, and the increased marketization of nature. Despite the popular argument that urban community gardens provide a sense of nature in the city, urban political ecology considers them to be elements of the built urban form (Classen, 2015) and as spaces of social production. However, the inherent qualities of nature should not be ignored as they determine the characteristics of the garden (Classen, 2015). For example, the biophysical characteristics of plants influence the social relations of capital associated with gardening (Classen, 2015). Researchers describe urban community gardens as political commitments that are expressed through practical arrangements of things and living beings in city space and they involves a variety of heterogeneous actors (Certoma et al., 2015).

In food studies, UPE recognizes the cultural, political, and economic processes responsible for outcomes of food systems, including food injustice (Agyeman et al., 2014). The co-production of nature and society leads to the emergence of distinct food systems and power geometries (Moragues-Faus, 2017). UPE in food studies investigates the dynamics of class, race, gender, and ethnicity issues, as well as power dynamics related to specific socio-environmental outcomes like uneven access to natural resources and ecosystem degradation (Peet and Watts, 1996; Galt, 2013). Many studies have analyzed the cooperation between local governments and civil society in the design and development of urban food policy (Christophers, 2018). Food systems create environmental problems like greenhouse gas emissions, environmental degradation, water pollution, and soil erosion, all of which are social in origin.

Food systems embed multiple interconnected socioeconomic, cultural, political, and ecological processes (Lang et al., 2009). Moragues-Fause et al. (2015) argues that cities represent urban 'spaces of deliberation' where the discourse about sustainable and just food systems takes place, followed by social and ecological innovation and transition practices. Their paper discusses how cooperation among civil society organizations, policy makers, and academics created a community of practice around urban food strategies (UFS) (Moragues-Fause et al., 2015). The goal of cities as spaces of deliberation is to create an urban foodscape that integrates consumption, public health, ecological integrity, and social justice (Moragues-Fause et al., 2015) with the principles of transparency, representation, accountability and democracy (Swyngedouw, 2005).

Overall, UPE argues that the people, institutions, policies, and regulations that emerge to respond to the environmental problems reflect the specificity of a place and, at the same time, reproduces the differences. UPE views urbanization as a complex and multiscale process of materials and networks that constitute cities, and how they shape the environment (Keil et al., 2015). Place-based research in UPE studies challenges the idea that all urban processes are experienced in the same way everywhere.

Governance of the "Commons"

Governance of the commons represents a social practice exercised by community members themselves through institutions that they create, and it involves a variety of informal mechanisms, such as values, norms, rules, and laws (Basu et al., 2017; Ostrom 1990). Previous research provides several definitions of "commons." In her work, Elinor Ostrom investigates commons as *a resource* that is accessed and used by a community according to established rules or protocols (Ostrom, 1990). She defines "common-pool resources" (CPR) as useful materials or processes that are available publicly and are "sufficiently large that it is difficult, but not impossible, to define recognized users and exclude other users altogether" (Ostrom, 2008). The more people use such resources, the less benefits are left for others. Hess (2008) applies the concept of CPR to infrastructure, knowledge, and culture. Common and Stagl (2005) distinguish CPR from "common-property resources," which can be owned and regulated by stakeholders, including groups of individuals, the government, and NGOs.

Ostrom's work on common-pool resources was elaborated upon by scholars who studied the "urban commons" or common resources in cities. Fennel (2015) compared this focus to Hardin's description of the commons: "the city's analog to placing an additional cow on the commons is the decision to locate one's firm or household, along with the privately-owned structure that contains it, in a particular position within an urban area" (Fennell, 2015, p. 1382). Urban commons are different from Ostrom's commons because they are congested, heavily regulated, and more socially and economically complex (Fennell, 2015). Therefore, management of urban common resources involves forms of nested governance, like the administrative branches of local government (Ela, 2016), other levels (county, state, and federal) of government (Hudson and Rosenbloom, 2013), and urban actors and sectors (Foster et al., 2018). The urban commons – open squares, community gardens, parks, buildings, and streets – have many purposes and uses that vary among users. Urban areas themselves can represent commons; constructed through social processes and institutional design (Madison, Frischmann, and Strandburg, 2010). For example, increased demand on urban space and goods and services provided by cities can result in rivalrous conditions when one person's use of space subtracts from the benefits of that space for others (Foster et al., 2018). Governance and management of the urban commons should allow their sharing as well as the production of new resources (Madison, Frischmann, and Strandburg, 2010). Colding and Barthel (2013) describe urban community gardens as a type of 'urban green commons' (UGCs): "physical green spaces in urban settings of diverse land ownership that depend on collective organization and management and to which individuals and interest groups participating in management hold a rich set of bundles of rights, including rights to craft their own institutions and to decide whom they want to include in such management schemes" (Colding and Barthel, 2013, p.159).

Gibson-Graham et al. (2013) discuss commons as a *process, activity, or a practice* that is shared by a community and can take place with any form of property: private, state- owned, or open access. They distinguish several types of commons

(Gibson-Graham et al., 2013):

• biophysical commons (for example, soil, sunlight, atmosphere, water, and plant and animal ecologies),

• cultural commons (for example, language, a musical heritage, and artworks),

• social commons (for example, educational, health, and political systems), and

• knowledge commons (for example, ecological knowledge, science, and technologies).

"Commoning" refers to the process of cooperation of multiple actors on the design and production of commons at different scales. (Bollier and Helfrich 2015). According to the Diverse Economies framework, commoning is guided by the principles of responsible use of commons with regard to each other and the environment (De Angelis, 2010; Gibson-Graham et al., 2013). Governance of commoning determines who creates the rules and protocols of use and access of the property, and how benefits are to be distributed. Poor governance (or absence of governance) leads to the tragedy of the commons (Ostrom, 1990; Hardin, 1968).

The difference between commons and things that are not common properties is "institutionalized sharing of resources among members of a community." (Madison, Frischmann, and Strandburg, 2014, p. 2). In common property systems community members collectively produce a set of rules for use, self-imposed norms, and social mechanisms to control and manage resources (Ostrom, 1990). Regardless how commons are viewed – as a category or a process - community members take care of them and distribute the benefits. Governing the commons requires consideration of the physical environment and the specific characteristics of a community (McGinnis, 1999). Ostrom (1990) proposed “design principles” that facilitate long-term, collective governance of commons as natural resources. These principles include the following management characteristics: 1) well-defined boundaries, 2) proportional equivalence between benefits and costs, (3) collective-choice arrangements, (4) monitoring, (5) graduated sanctions, (6) conflict-resolution mechanisms, (7) minimal recognition by governments of the rights of local people to organize, and (8) nested enterprises (Ostrom, 1990). Ostrom (1999, 2000a) suggests that successful governance is achievable by small and homogenous communities or groups that have a lot of social capital, a strong sense of community and mutual trust, possess authority to change the rules, depend on the resource, and operate with a low discount rate. Discount rates are choices to sacrifice benefits in the present to gain greater future benefits (Ostrom, 1990). Also, people are more likely to cooperate, monitor, and sanction if they know each other’s reputations and past behaviors (Acheson, 2011; North, 1990; Knight, 1992; Ostrom, 1990). Lack of communication, monitoring, and sanctioning can lead to overuse of a CPR (Ostrom, 1994). When new community members enter the group, they tend to adopt the predominating model of behavior in that group (Boyd and Richerson, 1985). According to Ostrom’s frameworks, a change in rules leads to changes in outcomes (Ostrom, 2005). Institutional analysis aims to understand the working rules and norms that affect decisions. One of the problems related to working rules is that there can be insufficient clarity, and this can lead to misinterpretations or conflicting interpretations of a rule among individuals (Allen, 2005; V. Ostrom, 1980, 1997, 2008). Therefore, it is important that those who create, enforce, and follow the rules, share a common meaning and clearly understand the terminology used to denote the rules (Ostrom, 2011). In other words, the rules should be designed so as they do not enable multiple interpretations.

Studies associate community gardens with neighborhoods' common goods or common resources (Teig et al., 2009). Some characteristics of goods include excludability and subtractability. Excludability describes one's ability to use the resource; subtractability describes how the use of the resource by one person affects others' use of the same resource (Acheson, 2011). Different governance approaches determine the levels of excludability and substractability of community gardens as well as associated property rights. Property rights represent the rules that regulate human-nature relationships (Hanna et al., 1996). Acheson (2011) gives a summary of Ostrom's five types of property rights: access (right to enter a physical area), extraction (right to appropriate resource units), management (right to regulate the use and maintain the resource), exclusion (right to grant access and extraction rights), and alienation (right to sell or transfer management and exclusion rights). Every property-right regime can incorporate several kinds of goods or vice versa (Acheson, 2011). Sometimes the production of common-pool resources occurs with insecure property rights, which means that "common-property resources are not automatically associated with common-property regimes – or with any other particular type of property regime" (Ostrom, 2003, 249).

The Diverse Economies framework by Gibson-Graham also proposes principles of successful governance of commons that go beyond the consideration of commons as natural resources. These principles consider the social value produced by the human interaction and involve the responsible use of commons with regard to each other and the environment. This research applies Gibson-Graham’s work on the governance of common resources to urban community gardens as biophysical, social, cultural and knowledge commons.

The Diverse Economies Framework

The Diverse Economies framework was first proposed by J-K Gibson-Graham (pen name of collaboration between Katherine Gibson and Julie Graham). In their work, Gibson-Graham argue against the mainstream idea of capitalism as a dominant and the most effective economic structure. In contrast, the diverse economy framework recognizes more than one direction for economic development and a variety of forms of labor, property, finance and markets that constitute different economies (Hill, 2015, p. 7). The diverse economy framework rethinks the economy by considering all activities of material survival rather than exclusively those selected by the dominant economic structure (Gibson-Graham, 2014). These activities (for example, co-housing movements, the global ecovillage movement, fair trade, economic self-determination, unpaid elder and health care, community supported agriculture, the social economy that put social goals above business goals, informal international financial networks, etc.) involve a wide range of social relations, including collective agreement, reciprocity, trust, care, cooperation, sharing, guilt, equity, solidarity, community pressure, environmental and social justice, etc. (Gibson-Graham, 2014). As a result, economic crisis or stability are experienced differently withing these activities and relations. In *The End of Capitalism (as We Knew It): A Feminist Critique of Political Economy* (1996), Gibson-Graham discuss various non-capitalist practices that exist in capitalist world and often stays unrecognized. Recognizing these practices that go beyond the capitalist mechanisms opens new possibilities and dimensions of human interactions with nature and each other. Capitalism limits roles that individuals play in the economy to labor and consumption (Gibson-Graham et al., 2013). Rather, the Diverse Economies framework considers multiplicity of tasks people perform in a diverse social space to surviving well, distributing surplus, encountering others, caring for commons, and investing for the future (Gibson-Graham et al., 2013). Diverse economy research analyzes why capitalist economies become dominant and seeks for the alternative systems that create 'community economy' — "a space of decision making where we recognize and negotiate our interdependence with other humans, other species, and our environment." (Gibson-Graham et al., 2013, p. 54). Community economy brings together people with different backgrounds, values and expectations whose goals are guided by the principles of 'ethical action' (Gibson-Graham, 2006), which include the following (Gibson-Graham et al., 2013, p. 53):

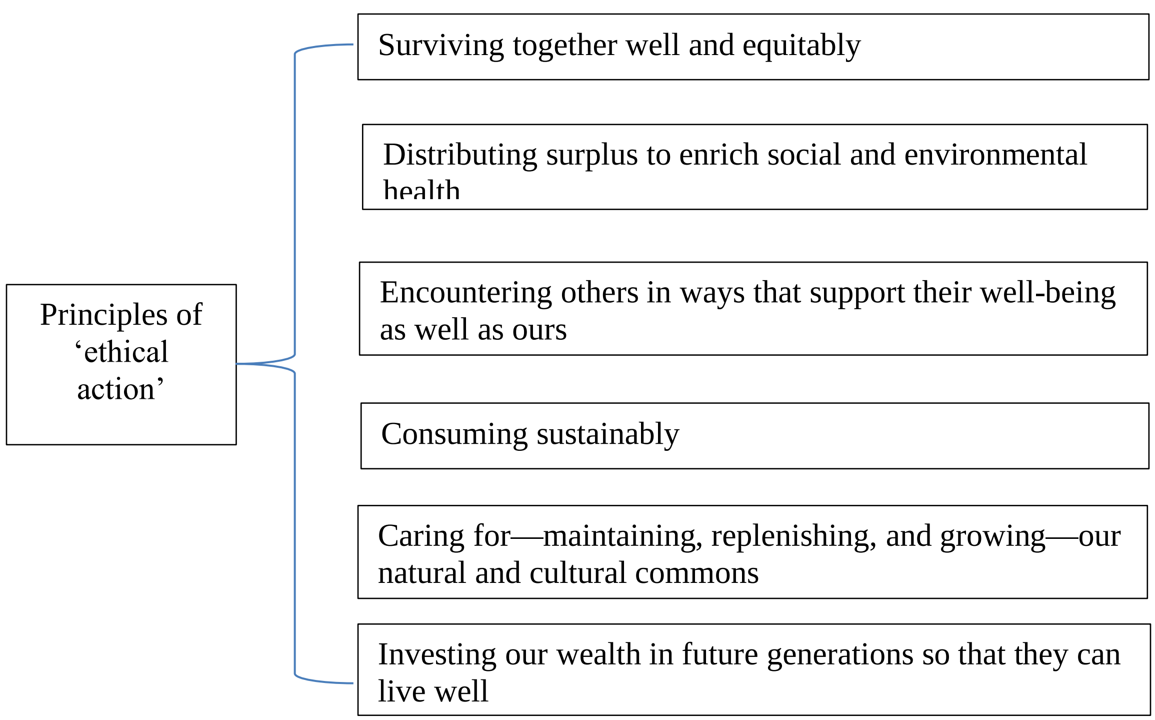


Figure 2: The principles of 'ethical action' (Gibson-Graham et al., 2013, p. 53).

Gibson-Graham (2008) describe the goal of ‘ethical dynamics’ as identifying “the individual and group decisions that influence the unpredictable trajectories of diverse economies” (Gibson-Graham, 2008, p. 625). Diverse economies extend the political ecology discourse by letting new voices to speak on the issues of resource use, resource rights and community economic development. Doreen Massey’s work provides an example of an ethical intervention that creates geographies of collective responsibility. Collective responsibility incorporates alternative practices that benefit all stakeholders and strengthen the relationship between them (Massey, 2007).

Community development scholarship utilizes the Diverse Economies framework to investigate the processes that produce certain values in the community and influence the way people think about how a community should look like. Carolan and Hale (2016) use the Diverse Economies Framework to explore other meanings of food, economy, community and collective action, different from the ones proposed by mainstream. For example, they investigate the value of urban agriculture that goes beyond the food supply and lies in social interactions, knowledge exchange and interaction with nature.

Typically, the “success” of community gardens is determined by examination of several types of community capital: natural, built, financial, political, social, human, and cultural capitals (Carolan and Hale, 2016); this is known as the Community Capitals Framework. It assumes that community members value all these types of capital. This assumption, however, can lead to the imposition of values on a community (Carolan and Hale, 2016). There is a need to understand how people’s experiences, networks, practices, and organizational forms, form and shape their values. The challenge is to understand which types of capital have more weight in a specific community. The

Diverse Economies Framework suggests that economies are based on the diverse socio-material networks and it is important to analyze why communities have certain values (Carolan and Hale, 2016). According to this framework, community values are not objectively given or imposed on a community but are built and shaped through their activities and communication. Carolan and Hale (2016) distinguish “above ground” community capitals (the values that are thought to be important for the community) and “below ground” diverse economies (what a community actually values the most – values determined by the habits of, traditions of, practices among, and interrelationships within a particular group of people or community). Fieldwork is a useful tool for this as it provides “below ground” analysis of people’s values and priorities, and their vision for their community.

Urban agriculture facilitates the production of social capital as people work alongside each other, share seeds, harvests, recipes, knowledge, common resources (e.g., water), and perform their duties and other activities together (Carolan and Hale, 2016; Carolan, 2011). If there are multiple stakeholders involved in urban agriculture projects, the tension between motivations and visions can be high (Milliken and Martins, 1996). On the other hand, a diversity in the membership of participants enriches its networks and partnerships, encourages innovative relationships, solidarity, and agency (Carolan and Hale, 2016). Carolan and Hale (2016, p. 541) argue that in successful urban agriculture projects people “feel like they are choosing to value all capitals equally, or at least with some degree of symmetry, as opposed to feeling as though they are being forced to do so.” This analysis utilizes the Diverse Economies framework to evaluate the gardens’ “success”. It examines community gardens as community economies that advocate for ‘ethical action’ as they synthesize the gardeners, other people, and the natural world through the Ostrom’s SES framework.

The SES Framework

Ostrom’s SES framework is used to study complex systems at multiple scales, and it is useful for the analysis of multiple governance models and their impacts on the resource systems (McGinnis and Ostrom, 2014). The SES framework is built on the assumption that individual and collective choices influence the results of collective action. A researcher can choose from variables established by the SES framework to explain the causal relationships defined by a theory used in their research. They can then construct a model to elaborate a theory using these variables. The SES framework facilitates the analysis of urban and rural ecosystem management by providing a common language for defining variables (Ostrom, 2007, 2009).

The original application of the SES framework was in common-pool resource management. The original “top-tier” variables included resource users, resource units, and a resource system (McGinnis and Ostrom, 2014). A revised SES framework included eight first-level core subsystems: social, economic, and political settings (S), related ecosystems (ECO), resource units (RU), a resource system (RS), a governance system (GS) and actors (A), the interactions (I) between them and the resulting outcomes (O) (Figure 3). These variables included multiple second- and lower-tier variables as well.

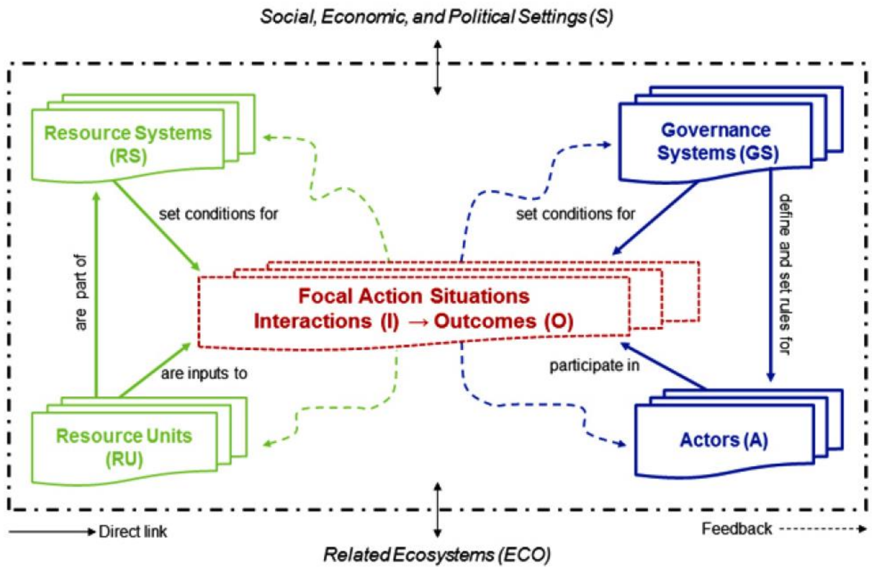


Figure 3: The revised SES framework with the top-tier variables (McGinnis and Ostrom 2014).

Related ECO and broader S provide a general context for all core variables. RS describes the environmental conditions in which the resources are located or produced. RU represent the natural resource units generated by the resource system. A includes all actors affecting or affected by the resource system. All the actions take place in action situations, where input is transformed into O. In turn, O can influence the initial variables. Action situations define the social spaces of interaction, problem solving, or exchange (Ostrom, 2011). It is important to understand who participates in action situations, what information and resources the participants possess, what their values are, as well as other factors and forces that influence strategical choices. GS includes the decision-making processes, and implementation and enforcement of rules and regulations related to SES management. Various institutional arrangements provide different incentives and opportunities to learn (Ostrom, 2011). The lack of information may lead to the wrong choice of strategies, which can be overcome over time as individuals participate in the decision-making and learn from past results (Ostrom, 2010; Boyd and Richerson, 1985). The longer individuals work together on policymaking the more likely their collaboration will lead to successful outcomes (Ghate, 2004; Shivakumar, 2005). Successful long-term governance of resources depends on many factors. Thus, effective governance considers the preferences of community members. According to Ostrom's principles of governance, successful collective resource management depends on well-defined boundaries. This is also beneficial for controlling and preventing negative processes (Delgaro-Serrano et al., 2015). Ostrom and Cox (2010) characterize governance systems based on their rules, property systems, and network structures.

Outcomes of the resource system are the result of both ecological and social processes and their interactions (Vogt et al., 2015). Vogt et al. (2015) argue that the initial SES framework fails to fully understand human-environment problems because it does not include ecological components and focuses solely on the social production of outcomes. Incorporation of ecological theory expands the implication of the SES framework (Vogt et al. 2015). Epstein et al. (2013) proposed addition of ecological variables to the SES framework and stressed that they are as important as existing social processes that are already included in the framework. Others suggested that ecological dynamics influence the process of choosing operational rules (Janssen 2010). In a study of Yellowwood Lake Watershed (YLW), Vogt et al. (2015) expanded the RS and RU core subsystems by including ecological variables. Delgado-Serrano et al. (2015) also suggested modifications of the framework by expanding on lower-tier variables to make it applicable to place-based research.

The SES framework is holistic because it integrates social, economic, ecological, and governance factors externally and internally, as well as their interactions and outcomes (Delgaro-Serrano et al., 2015). SES is also multi-layered and nested (Janssen and Anderies, 2013). SES can be used to analyze community gardening because it considers social and ecological aspects and their interactions, includes qualitative and quantitative data, proposes a variety of sub-variables, focuses on the governance and management of natural resources, and focuses on the role of community members in the process of governance. Moreover, it can be used to analyze the impacts of users' self-organization rules on sustainability (Delgaro-Serrano et al., 2015). Each community garden represents an example of a resource systems. All gardens combined can be considered a single resource system. Gardening practices represent actions through which input variables are transformed into outcomes. The community gardens analysis, through the lenses of the SES framework, strives to understand how rules and regulations for use, the biophysical characteristics of gardens, and attributes of a community affect the decision-making process and gardening outcomes.

Conceptual Model, Research Questions and Research Objectives

This study adapts UPE theory because it integrates the social, ecological, and political processes that interact to produce spatially unique byproducts (community gardens) to reflect the influence of "place" created by the interplay of urban political ecological relationships. Political processes in community gardens are expressed through the distribution of power and governance structure of gardens. The power dynamic reveals who is involved in decision-making and the creation of rules and regulations. Community gardens provide a space to negotiate, find consensus, make decisions, create rules, and implement them. This gives gardens new meanings and new value. Therefore, community gardens represent an example of the production and governance of space by community members, requiring political knowledge and skills, for example, in land use management, zoning, and economic development (Purcell et al., 2014).

The SES framework enables organization of the elements of urban political ecology theory – the social, ecological, and political aspects –to explain the differences in socio-ecological and spatial outcomes among the community gardens (Figure 4).

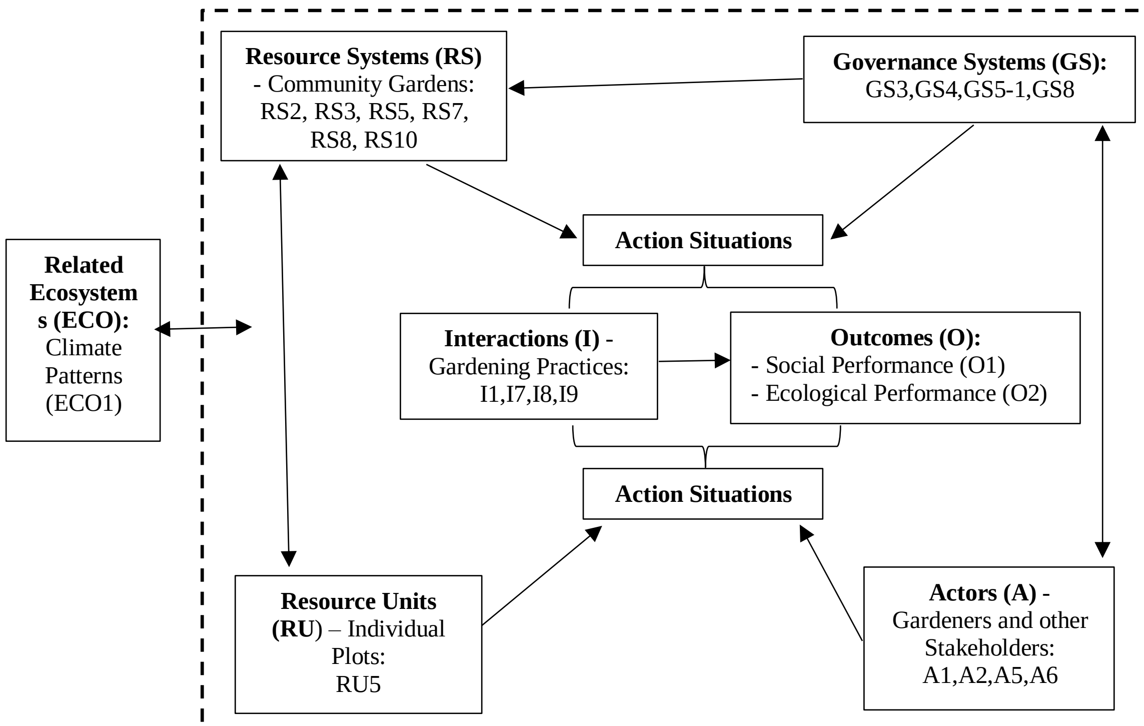


Figure 4: Modifying the SES framework to study community gardens.

Each community garden is a case of an RS, consisting of individual plots or RU. Actions provide a platform to create different socio-ecological outcomes (O) through gardening practices (I). Community gardening involves actors (A) (i.e., gardeners and other stakeholders). In some gardens, the gardeners do not participate in management or decision-making, while in others they are involved in everything. The GS of community gardens represent a variable in the SES framework that influences other elements. And climate conditions of region (ECO) affect gardening and productivity. This study uses both the original and modified versions of SES of Ostrom (2009), McGinnis and Ostrom (2014), and Vogt et al. (2015) and proposes third-tier variables specific to analysis of community gardens (Table 2).

Table 2: Second- and third-tier variables of the SES framework from Ostrom (2009:421) applicable for studying community gardens. Asterisks indicate factors proposed by this research. Double asterisk indicates a variable proposed by Vogt et al. (2015).

SES Variable (code)	SES Variable (name)	Explanation/Reason for inclusion
Related Ecosystems (ECO)		
ECO1	Climate patterns	This variable includes climate characteristics that are common for all the community gardens in Austin, TX. It affects ecological performance measures (O2)
Resource Systems (RS)		
RS2	Clarity of system boundaries	
RS2-1*	Researcher-defined boundaries of a resource system through on-screen digitizing	This variable affects ecological performance measures (O2)
RS3	Size of resource system	
RS3-1*	Researcher-defined size of resource system	This variable includes gardens' areas and affects ecological performance measures (O2)
RS5	Productivity of system	This variable includes Normalized Difference Vegetation Index (NDVI). It affects ecological

		performance measures (O2)
RS7	Predictability of system dynamic	
RS7-1*	Consistency of activity related to resource system	This variable describes a consistency of gardening activities. It affects both social and ecological performance measures (O1, O2)
RS8	Storage characteristics	This variable estimates the amount of water stored (Evaporation Stress Index). It affects ecological performance measures (O2)
RS10**	Ecosystem history	
RS10-1*	The longevity of resource system	This variable describes how long a garden exists. It affects both social and ecological performance measures (O1, O2)
Research units (RU)		
RU5	Number of units	This variable includes the number of garden plots. It affects manual delineation of gardens' boundaries through on-screen digitizing
Actors (A)		
A1	Number of relevant actors	This variable includes the number of gardeners and describes the level of participation. It affects both social and ecological performance measures (O1, O2)
A2	Socioeconomic attributes	This variable includes socioeconomic and demographic characteristics of the gardeners. It affects social performance measures (O1)
A5	Leadership/entrepreneurship	This variable describes a model of governance and affects social performance measures (O1)
A6	Norms (trust-reciprocity)/social capital	This variable affects both social and ecological performance measures (O1, O2)

Governance systems (GS)		
GS3	Network structure	This variable includes the number and types of stakeholders involved in a community garden
GS4	Property-rights systems	This variable indicates who owns the land on which a community garden operates
GS5-1*	Rules and protocols	This variable describes who establishes and implements rules and protocols
GS8	Monitoring and sanctioning rules	This variable describes who is in charge of monitoring and sanctioning
Interactions (I)		
I1	Harvesting	This variable includes gardening activities related to crops/vegetables/fruits production as well as planting of flowers
I7	Self-organizing activities	This variable includes activities related to self-governance, garden's maintenance, formal and informal environmental education and leisure activities
I8	Networking activities	This variable includes activities related to funding, external stakeholders, tenure secure, promotion, distributing surplus, etc.
I9	Monitoring activities	This variable includes the process of monitoring
Outcomes (O)		
O1	Social performance measures	Gardeners' perceptions of their success
O2	Ecological performance measures	The seasonal differences in carbon sequestration

Community gardens require collective action (Petrovic et al., 2019). Collective action is action taken by a group of people to achieve a common objective (Poteete et al., 2010; Rydin and Pennington, 2000). The collective actions of a community garden's members relate to the garden's preservation and maintenance through political activism, fundraising, grant-seeking, repair, garbage disposal, etc. (Petrovic et al., 2019). Overcoming the barriers to success also requires collective action (Diaz et al., 2018). SES variables can be facilitators of or barriers to collective action. Ostrom and Ann (2003) identified the three attributes of collective action: extant networks, trustworthiness, and rules and norms for solving collective-action problems. Other studies added networking with institutions and state organizations as an additional characteristic of collective action in urban contexts (Stoker 2000; Bourdieu 1986; Portes 1998). Studies have suggested that successful governance depends on monitoring, sanctioning, and secure tenure (Pagdee et al. 2006; Vogt et al., 2015).

The original version of the SES framework includes ten variables that relate to self-organized systems (Ostrom, 2009): size, productivity, and predictability of the resource system; extent of mobility of resource units; existence of collective-choice rules that users may adopt authoritatively to change their own operational rules; and four actor attributes (number of actors, having leaders, knowledge of SES, and the importance of the SES to the actors). This study uses five of them: size, productivity, existence of collective-choice rules, number of actors, and having leaders. Four additional third-tier variables are added as well: Researcher-defined boundaries of a resource system through on-screen digitizing (RS2-1) are derived from manual delineation of gardens' boundaries in GIS software if these data are not available; A researcher-defined resource system size

(RS3-1) is calculated based on RS2-1; Consistency of activity related to the resource system (RS7-1) determines the frequency of community members' participation, reflecting the level of attachment to the garden and the strength of social capital which affects a garden's productivity and its ecosystem services; And the longevity of the resource system (RS10-1) based on the age of the garden, which affects socio-ecological outcomes through the consistency of gardening – older gardens tend to have stronger and more extensive networks.

Outcome includes both social performance and ecological performance measures. Social performance is measured by the level of satisfaction or "success" derived from gardening. Instead of assuming the success of a garden based on the elements described in the literature, this study uses the diverse-economies framework by allowing gardeners to evaluate their gardens' success based on their own perspectives. Ecological performance analyzes community gardens' success through an environmental dimension by evaluating ecosystem service production. The seasonal differences in carbon dioxide uptake were analyzed by choosing a representative period for a growing and non-growing season, respectively. The seasonal difference in the NPP were calculated for each garden. This difference depends on multiple factors: climate, garden's size, and time and effort invested in gardening by community members. This does not imply that gardening is positively associated with carbon sequestration, but rather, the goal is to determine the factors that affect the ability of gardens to sequester carbon dioxide and to discern the roles that different approaches to governance play in this process. The SES framework can uncover the causal relationships between governance models and their impacts on the resource systems. According to SES, individual and collective choices influence the outcomes of a collective action (McGinnis and Ostrom, 2014). This research studies how governance approach affects both social and ecological performances using SES variables nested in UPE and the diverse-economies theories. There are three main research questions and objectives:

Research Question 1: What types of governance approaches do community gardens in Austin use?

Research objective 1: Through the qualitative analysis of key informants' interviews, examine the models of governance implemented in community gardens in Austin, TX, using the topology described by McGlone et al. (1999) and Fox-Kämper et al. (2018). The SES variables related to this objective include GS3 (Network structure), GS4 (Property-rights systems), GS5-1 (Rules and protocols), GS8 (Monitoring and sanctioning rules), A5 (Leadership/entrepreneurship).

Research Question 2: How do the members of community gardens evaluate the success of their gardens?

Research objective 2: Through the analysis of key informants' interviews, evaluate the social benefits of gardening in terms of the level of gardeners' satisfaction from an assortment of outcomes. The SES variables related to this objective include RS7-1 (Consistency of activity related to resource system), RS10-1 (The longevity of resource system), RS3-1 (Researcher-defined size of resource system), A1 (Number of relevant actors), A2 (Socioeconomic attributes), A5 (Leadership/entrepreneurship), A6 (Norms (trust-reciprocity)/social capital), O1 (Social performance measures).

Research Question 2A: What is the relationship between models of governance and community gardeners' perceptions of success?

Research Objective 2A: Using inferential statistics, examine the role of different models of governance in gardeners' perceptions of their success through the lenses of UPE and the SES frameworks. The SES variables related to this objective include O1 (Social performance measures).

Research Question 2B: What is the relationship between the success of community gardens and their commitment to the principles of 'ethical action'?

Research Objective 2B: Investigate whether the governance approaches associated with different levels of satisfaction expressed by the gardeners in Austin, Texas, include the principles of 'ethical action' described by the Diverse Economies framework.

Research Question 3: How does carbon sequestration compare between growing and non-growing seasons?

Research objective 3: Evaluate the ecological services provided by community gardens as urban green spaces by calculating the amount of sequestered carbon and examine the role of human factors in these services by calculating the seasonal differences. A representative period was be selected for each season (a growing and a non-growing). The seasonal difference in the NPP was calculated for each garden. This difference depends on multiple factors: climate, garden's size, and time and effort invested in gardening by community members. The SES variables related to this objective include ECO1 (Climate patterns), RS2-1 (Researcher-defined boundaries of a resource system through on-screen digitizing), RS3-1 (Researcher-defined size of resource system), RS5 (Productivity of system), RS7-1 (Consistency of activity related to resource system), RS8 (Storage characteristics), RS10-1 (The longevity of resource system), RU5 (Number of units), A1 (Number of relevant actors), A6 (Norms (trust-reciprocity)/social capital), O2 (Ecological performance measures).

Research Question 3A: What is the relationship between models of governance and seasonal differences in carbon sequestration?

Research Objective 3A: Using inferential statistics, examine the role of different models of governance in seasonal differences in carbon sequestration through the lenses of UPE and the SES frameworks. The SES variables related to this objective include O2 (Ecological performance measures).

Research Question 3B: What is the relationship between levels of carbon sequestration and community gardens' commitment to the principles of 'ethical action'?

Research Objective 3B: Investigate whether the governance approaches associated with different seasonal differences in carbon uptake include the principles of 'ethical action' described by the Diverse Economies framework.

With these questions and objectives in mind, the following section describes the study area, research design, related data collection and methods of analyses.

CHAPTER III

METHODOLOGY, DATA, AND RESEARCH DESIGN

Study Area

This study will focus on Austin, Texas, USA (Figure 5), the eleventh most populated city of the United States, and fourth most populous in Texas (US Census Bureau, 2019). The 2019 estimate of population, 978,908, is 23 percent more than the 2010 total (U.S. Census Bureau, 2019), making Austin the fastest-growing large city in the United States (Weissmann, 2015).

Figure 5: Austin and other major cities in Texas.

Austin is located on the Colorado River in Central Texas, along the Balcones Escarpment. The Balcones Escarpment, in Central Texas, delineates a boundary between Gulf Coastal Plains to the east and the Great Plains to the west. Austin has a humid subtropical climate (Köppen climate classification), experiencing hot summers and relatively mild winters (Source: NOAA "Austin Climate Summary", 2011). The climate creates a very diverse ecological and biological profile (Source: NOAA "Austin Climate Summary", 2011). The average annual rainfall, 34.32 inches (872 mm), is distributed fairly evenly throughout the year, though spring and fall are the wettest seasons (Source: "U.S. Climate Data" https://www.usclimatedata.com/), making them the prime growing seasons in this region (Petersen, 2001). The soils range from shallow, gravelly clay loams over limestone to deep, fine sandy loams, silty clay loams, silty clays or clays. Many of these, for example the clay-rich types, are slightly-to-moderately alkaline and have free calcium carbonate (Fowler, 2010). Austin experiences about 60.3 percent of total possible bright sunshine per year (Source: "U.S. Climate Data" https://www.usclimatedata.com/) (Table 3). The city of Austin is located within the gardening zone III (Texas Gardening Regions, USDA Plant Hardiness Zone Map, 2012) and is in plant-hardiness zone 8a (USDA Plant Hardiness Zone Map, 2012). Temperature and precipitation patterns dictate the need to plant drought resistant and low water usage crops. Thus, Austin’s climate facilitates year-round cultivation and promotes gardening.

Austin’s community gardening began about 40 years ago. The Coalition of Austin Community Gardens (CAGG) was created in 2008 to support the development of community gardens in Austin and to establish a network for participants. CACG promotes the establishment of new community gardens in the greater Austin metropolitan area and monitors existing ones to foster stability and land security for existing gardens, and to help them to thrive through advocacy and gardener education opportunities (Source: https://communitygardensaustin.org/about/). CACG cooperates with other

Table 3: Monthly average temperature and sunshine in Austin, TX (NOAA "Austin Climate Summary", 2011)

Month	Monthly mean temperature		Average Daily Sunshine Hours
	F	C	
January	54	12	6
February	55	13	7
March	63	17	9
April	70	21	10
May	75	24	11
June	81	27	12
July	86	30	13
August	86	30	13
September	81	27	11
October	72	22	9
November	61	16	8
December	55	13	6

organizations – the Sustainable Food Center and the City of Austin's Sustainable Urban Agriculture and Community Gardens program. There are fifty-one known community gardens located within the boundary of the City of Austin (CAGG Website), twenty-six of them participated in this analysis (Figure 6). The city defines a city-supported community garden:

"CITY-SUPPORTED COMMUNITY GARDEN means eligible city land controlled under a license agreement or non-city land controlled under a land control document which is issued a garden permit and located in the city corporate limits or extraterritorial jurisdiction by a non-profit organization that:

(a) is used by a group of four or more participating gardeners either on separate plots or farmed collectively by the group to grow, produce and harvest food crops for personal or group use, consumption or donation by the non-profit organization or cooperatively for the benefit of its members,

(b) is operated in a manner that includes water conservation, and in the case of eligible city land includes composting, non-polluting, and integrated pest management practices that promote a sustainable garden, and is cultivated solely for the production of organic produce,

(c) may include common areas maintained and used by the group for nonfood, ornamental crops,

(d) is platted as a legal lot or exempted under Section 25-4-3 (Temporary Exemption from Platting Requirements), and

(e) has a community garden zoning use classification." (City of Austin, 2019)

The total area of 26 analyzed community gardens in Austin is 65,079 square meters (16.08 acres).

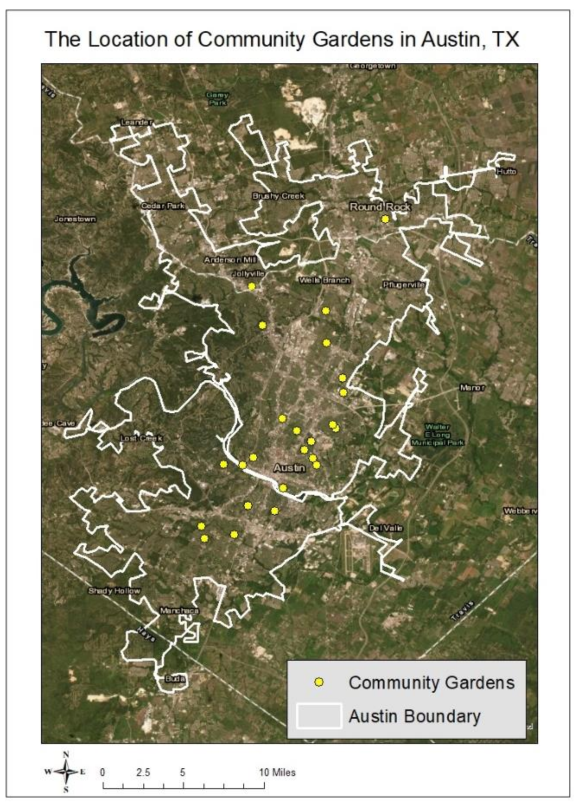


Figure 6: The locations of community gardens in Austin, TX.

Research Design

The questions posed require a combination of qualitative and quantitative data and a mixed-methods analysis. This study has three main questions, some of which have sub-questions. The data and methods to answer these questions are described below (Table 4), but it is important to explicitly state that this study will employ a concurrent transformative design. Concurrent designs involve parallel collection of qualitative and quantitative data. In concurrent transformative designs, the research process is informed by a theoretical perspective/conceptual model (Sharon and Halcomb, 2009). The qualitative data are the dominant form of data because they are used to explain the results of quantitative analyses. Qualitative data were collected through key-informant interviews (Appendix A). The sources of quantitative data include key-informant interviews as well, but also satellite data. Though the qualitative and quantitative data were collected at the same time, the qualitative data were analyzed first to answer the first research question. The results of the qualitative analysis will be used to explain the results of the quantitative analyses.

Data Collection and Methods

Qualitative Data

Qualitative data include key-informant interviews (Appendix A). The list of questions has been approved by Institutional Research Board (approval # 6416, approved on 03/18/19). The interview questionnaire was sent via email to community gardens' contact persons (Appendix B). The key informants (gardens' contact persons or other appointed individuals) participated in the questionnaire either via email or via phone.

Table 4: Summary of research questions, methods and data sources

Research questions	Data Acquisition + Preparation		Data Analysis	
	Source	Manipulation	Method of Portrayal	Method of Analysis
RQ1: What types of governance approaches do community gardens in Austin use?	Key-informant interviews	Original Data, Creation of categories	Graph, Table, Diagram	Descriptive Analysis, Content Analysis, Flowchart Analysis
RQ2: How do the members of community gardens evaluate their success?	Key-informant interviews	Original Data, Creation of categories	Graph, Table, Diagram	Descriptive Analysis, Content Analysis
RQ2A: What is the relationship between models of governance and community gardeners' perceptions of success ?	Key-informant interviews	Original Data, Creation of categories	Graph, Table, Diagram	Explanatory Analysis
RQ2B: What is the relationship between the success of community gardens and their commitment to the principles of 'ethical action'?	Key-informant interviews	Original Data, Creation of categories	Graph, Table, Diagram	Descriptive Analysis, Content Analysis
RQ3: How does carbon sequestration compare between growing and non-growing seasons?	ECOSTRESS/ PlanetScope/ NCAR	Conducting in ArcGIS 10.7, R Studio	Remote sensing images, graph, table	Carnegie-Ames-Stanford approach (CASA), two-sample t-test
RQ3A: What is the relationship between models of governance and seasonal differences in carbon sequestration?	Key-informant interviews/ Remote sensing data	Original Data, Creation of categories	Graph, Table, Diagram	Explanatory Analysis
RQ3B: What is the relationship between levels of carbon sequestration and community gardens' commitment to the principles of 'ethical action'?	Key-informant interviews	Original Data, Creation of categories	Graph, Table, Diagram	Descriptive Analysis, Content Analysis

Data from key informant interviews served to determine: 1) the types of governance approaches used by community gardens in Austin, 2) gardeners' perceptions of the success, and 3) the principles of 'ethical action' proposed by the Diverse Economies framework. Twenty-six community gardens participated in the interview process. Qualitative data has been collected during COVID-19 pandemic, which affected the process of data collection. It took longer than expected for the key-informants to turn in their questionnaires, specifically when they wanted to discuss the list of questions with other garden's participants prior answering them. These difficulties relate to social distancing, a crucial measure for slowing the spread of COVID-19.

Quantitative Data

<u>GIS Data</u>

The location of the gardens was geocoded from the addresses provided by the CACG using ArcGIS for Desktop Standard 10.4.1 software (Figure 6). The garden's boundaries were manually delineated in ArcGIS based on the high-resolution Google Earth imagery (Möller et al., 2007). The gardens' areas differ from the lot areas where they are located because the lots include buildings and sometimes parking areas, which do not participate in the carbon uptake. Manual delineation of gardens' boundaries allows excluding these elements from the analysis. Previous studies suggest that high resolution remote sensing imagery of 5 meters or less allows an accurate delineation of the site's boundaries (Forkuor et al., 2014). Establishment of the boundaries allowed calculation of gardens' areas (Equation 1):

Area (m^2) =Number of pixels * Pixel area (Tripathi et al., 2010) (1)

The total area of 26 analyzed community gardens in Austin is 65,079 square meters (16.08 acres) (Appendix D).

Satellite Data

Two sources of satellite data were used – ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and PlanetScope imagery. ECOSTRESS is a NASA product designed to measure the temperature of plants (Jewell and Fisher, 2018). Plant temperatures rise when they do not receive enough water. ECOSTRESS provides the most accurate and detailed temperature satellite images of Earth's surface that can be used for the small-scale analysis (Source: NASA).

ECOSTRESS data include four levels of data processing, with data granules defined as an image scene (Table 5). The satellite orbits are defined as equatorial-crossing ascending International Space Stations (ISS) orbit, and each image scene starts at the beginning of the first target area encountered during each orbit (Jewell and Fisher, 2018). Spatial resolution of ECOSTRESS images is 70 m.

Table 5: ECOSTRESS products description

Product type	Description of data
Level 1	Spacecraft engineering data
Level 2	Land surface temperature, emissivity, and cloud mask
Level 3	Evapotranspiration derived from Level 2 data
Level 4	Evaporative stress index and Water use efficiency derived from Level 3 data

This research utilizes the ECOSTRESS Level 4 Evaporative Stress Index (ESI). The ESI indicates surface moisture conditions and is defined as the ratio of evapotranspiration (ET) to potential evapotranspiration (PET) (ET/PET) (Otkin et al., 2014). A ratio close to zero indicates limited water supply (Fisher, 2013). ESI is unitless and ranges from 0-1, with 0 being full water stress, 1 being no water stress (Fisher and ECOSTRESS Algorithm Development Team, 2015).

Planet is a corporation that designs, builds, and launches satellites to acquire images for geospatial analysis. Planet's satellites orbit the poles every 90 minutes, capturing the entire Earth's landmass every day (Planet Team, 2019). This research utilizes remote sensing images taken by the PlanetScope satellite. The PlanetScope imagery includes three product lines: a Basic Scene product, an Ortho Tile product, and an Ortho Scene product (Planet Imagery Product Specifications, 2019). This analysis uses PlanetScope Ortho Scene product, which is the single-frame image that went through the additional post processing (Planet Imagery Product Specifications, 2019). PlanetScope scenes are comprised from four spectral bands (Blue: 455 - 515 nm, Green: 500 - 590 nm, Red: 590 - 670 nm, NIR: 780 - 860 nm) and have a spatial resolution of approximately 3 meters.

Methods of Data Analysis

Methods of Analysis for Research Question 1

Governance approaches utilized by community gardens were determined using descriptive analysis. The key informant interviews were analyzed using content analysis and open coding, i.e., allowing the data to present themes (Gibbs 2007). Open coding is the processes of analyzing textual content that involves labeling concepts and defining categories of qualitative data based on their properties (Seidel and Kelle, 1995). This analysis applies deductive coding process. Deductive coding starts with a predefined set of codes, which are assigned to the qualitative data (Medelyan, 2019). The analysis of governance approaches utilized by community gardens in Austin focuses on the *Governance Systems (GS), Actors (A)* and *Interactions (I)* blocks from the SES framework (Figure 7).

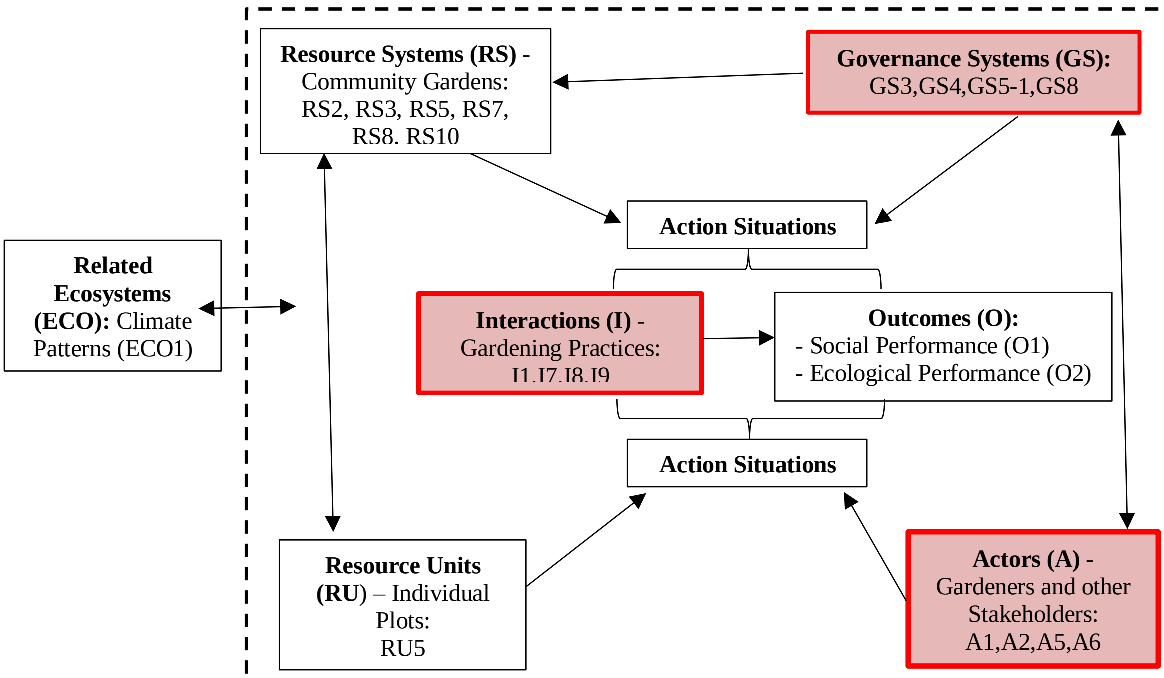


Figure 7: The SES framework to analyze governance approaches utilized by community gardens

The SES variables assigned to these blocks serve as codes to analyze the gardener's answers to understand the degree of the involvement of local government and NGOs in the governance of community gardens (Table 6).

Table 6: The SES variables used as codes to analyze types of governance.

Open Code	Properties	Examples of participants' words
A5 Leadership/entrepreneurship	Describes a model of governance	governed by a Board of Directors a Steering Council a core group of 4-5 leaders an informal committee a selected President
GS3 Network structure	Includes the number and types of stakeholders involved in a community garden	Gardeners (founders, volunteers, members) the Sustainable Food Center (SFC) Rollingwood Women's Club St. David's Foundation
GS4 Property-rights systems	Indicates who owns the land on which a community garden operates	the City of Austin a church Austin Independent School District a member-owned and run cooperative
GS5-1 Rules and protocols	Describes who establishes and implements rules and protocols	CG Steering Council self-written By-Laws
GS8 Monitoring and sanctioning rules	Describes who is in charge of monitoring and sanctioning	an informal leader a Board of Directors
I1 Harvesting	This variable includes gardening activities related to crops/vegetables/fruits production as well as planting of flowers	Sustaining biodiversity Wide variety of regionally suited vegetables and herbs

		Plant fruit/nut trees
I7 Self-organizing activities	This variable includes activities related to self-governance, garden's maintenance, formal and informal environmental education and leisure activities	park clean up and maintenance events 'hands-on' learning about sustainable food regularly-held social events Labor Day party environmental classes weekly meetings
I8 Networking activities	This variable includes activities related to funding, external stakeholders, tenure secure, promotion, distributing surplus, etc.	collaboration with a local assisted living home building partnerships with local businesses learning lab for Cunningham Elementary students donate food to a nearby food bank donate to the women's shelter
I9 Monitoring activities	This variable includes the process of monitoring	a lead who guides the others Manager

The answers to the following questions from the questionnaire (Appendix A) were transcribed and coded to determine the corresponded SES variables describing governance approaches utilized by community gardens:

Question #3. Who owns the land on which your community garden operates? (Is it publicly or privately owned?)

Question #4. How is your community garden governed? In other words, who is responsible for the decision-making in your garden and who is involved in its management?

Question #5. Please describe some management techniques or strategies that you use to achieve the goals of your community garden.

Question #7. Do you receive funding from external sources? Would you please name the sources of your funding?

Next, the flow chart was used to determine different categories of governance utilized by gardens (Figure 8):

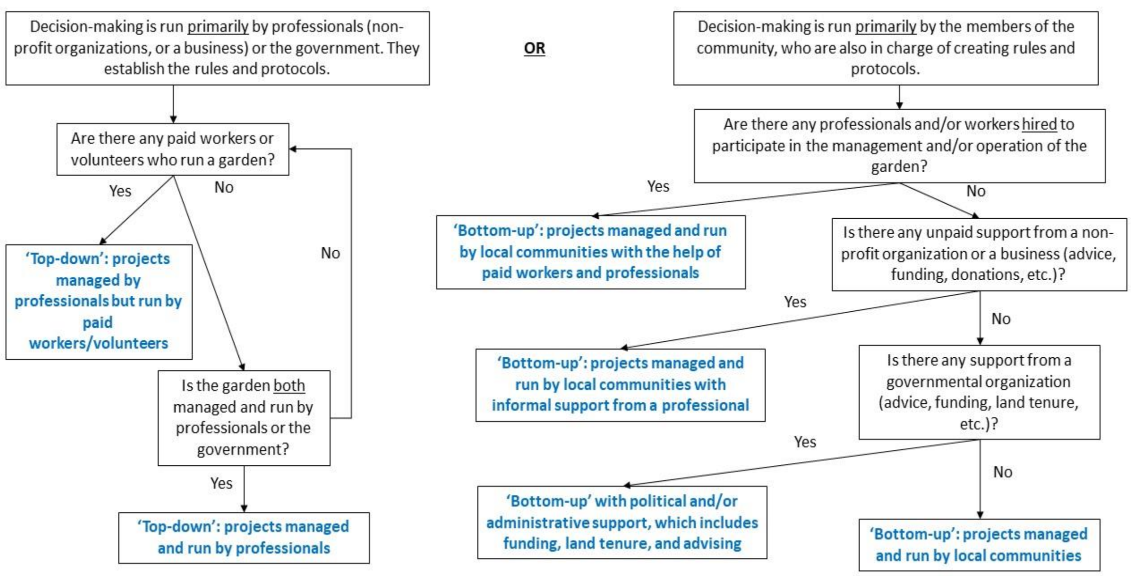


Figure 8: Criteria to determine the model of governance.

Methods of Analysis for Research Question 2

Analysis of members' perceptions of the success of community gardens focuses on the *Resource Systems (RS)*, *Actors (A)* and *Outcomes (O)* blocks from the SES framework (Figure 9).

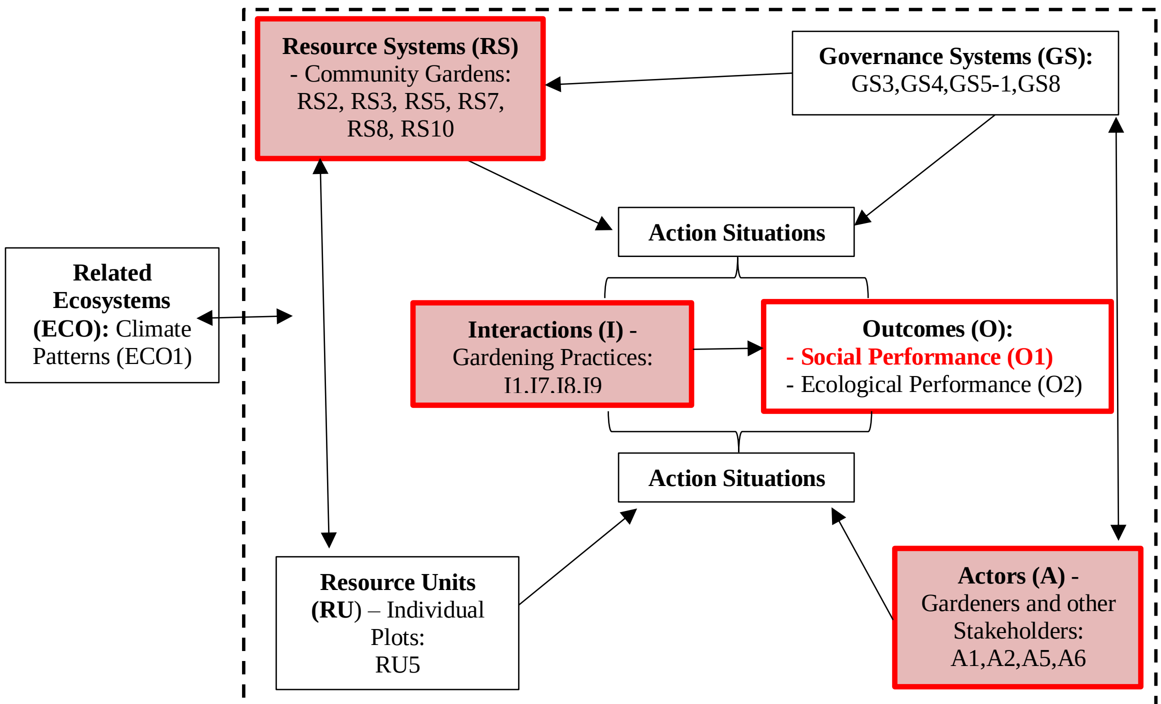


Figure 9: The SES framework to analyze community gardeners' perceptions of success.

The last question on the questionnaire asks community gardens' representatives to indicate their perceptions of the success of their community garden by checking the appropriate box on the LIKERT scale from 'unsuccessful' to 'very successful' (Appendix A). The SES variables RS7-1, RS10-1, A1, A2, A5, A6, O1 (Table 7) served to understand the gardeners' perceptions. Data analysis for research question 2 applied content analysis.

Table 7: The SES variables used as codes to analyze members' perceptions.

Open Code	Properties	Examples of participants' words
RS7-1 Consistency of activity related to resource system	Describes a consistency of gardening activities: regularity of workdays, level of participation	Participation is stable/growing/decreasing Garden membership is constantly revolving and evolving Gardeners coming each day Monthly workdays/ assigned days to tend the garden
RS10-1 The longevity of resource system	Describes how long a garden exists. Includes a year when a garden was established	2009 1978 November 2011
A1 Number of relevant actors	Includes the number of gardeners and describes the level of participation	15 gardeners 25 members members from six households 56
A2 Socioeconomic attributes	Includes socioeconomic and demographic characteristics of the gardeners	Age is for 60+ Seniors, Mostly Asians Families or couples in their late 20's/30s Post-grad students at the University of Texas
A5 Leadership/entrepreneurship	Describes a model of governance	governed by a Board of Directors a core group of 4-5 leaders an informal committee a selected President
A6 Norms (trust-reciprocity)/social capital	Includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit	Social exchange Social events Community work days to

		encourage group cohesion outreach to the neighborhood sharing of knowledge
O1 Social performance measures	Gardeners' perceptions of the success of their community garden	on the LIKERT scale from 'unsuccessful' to 'very successful'
I1 Harvesting	This variable includes gardening activities related to crops/vegetables/fruits production as well as planting of flowers	Sustaining biodiversity Wide variety of regionally suited vegetables and herbs Plant fruit/nut trees
I7 Self-organizing activities	This variable includes activities related to self-governance, garden's maintenance, formal and informal environmental education and leisure activities	park clean up and maintenance events 'hands-on' learning about sustainable food regularly-held social events Labor Day party environmental classes weekly meetings
I8 Networking activities	This variable includes activities related to funding, external stakeholders, tenure secure, promotion, distributing surplus, etc.	collaboration with a local assisted living home building partnerships with local businesses learning lab for Cunningham Elementary students donate food to a nearby food bank donate to the women's shelter

Models of governance that associated with the highest perceptions of success were revealed to determine the most effective organization and management structures. The assumption is that community gardens that are more autonomous have higher levels of perceived success. Data from the key informant interviews were used to determine whether these governance approaches follow the principles of ‘ethical action’ described in Figure 2. The answers to the following questions from the questionnaire (Appendix A) were transcribed and coded to determine principles of ethical action incorporated in community gardens’ governance:

Question #1. What is the purpose of your community garden? What are your primary and secondary goals?

Question #5. Please describe some management techniques or strategies that you use to achieve the goals of your community garden.

Question #8. Is your garden open to the general public? Is membership eligibility defined by a specific community or neighborhood? Who can join? Do you have a waiting list for access to a garden plot?

Question #13. Please identify any issues, problems, or concerns that you are experiencing in your community garden.

Methods of Analysis for Research Questions 3

Carbon sequestration by community gardens in Austin, TX was measured using net primary productivity (NPP). NPP is a variable that describes the growth of vegetation vis-à-vis the carbon cycle (Field et al., 1995). This paper applies the Carnegie-Ames-

Stanford approach (CASA) for calculating carbon sequestration used by the previous research (Tripathi et al., 2010; Field et al., 1995; Potter et al., 1993) to test it on a scale of a community garden (Equations 2 to 7). The CASA algorithm (Table 8) represents a biosphere model that “runs on a monthly time interval to simulate seasonal patterns in net plant carbon fixation, biomass and nutrient allocation.” (Potter et al., 1993, p. 811):

$$NPP = APAR*LUE \quad (2)$$

$$NDVI = APAR/PAR \quad (3)$$

$$NDVI = NIR-RED/NIR+RED \quad (4)$$

$$\text{therefore, } NPP = NDVI*PAR*LUE \quad (5)$$

$$LUE = \varepsilon°*T1*T2*W \quad (6)$$

$$W = 0.5+ ESI \quad (7)$$

Two values of NPP were calculated for each of the community garden: one for a growing season (t1) and one for a non-growing season (t2). July was chosen as a non-growing season based on the information provided by the community gardens’ representatives. Spring planting season in the Austin area occurs in March and April, with seasonal plants reaching their maximum growth in April and May respectively (based on the information from the community gardens’ representatives). Fall planting season typically occurs in September and October. The dates vary based on the vegetable/crop type. May was chosen as a growing season based on the examination of the Austin’s climate data ("Austin Climate Summary", 2011), availability of remote sensing data, and the information provided by the local gardeners.

Table 8: Variables used to calculate carbon sequestration.

Variable	Description	Units
NPP	Net Primary Production	g (grams)
PAR	Photo-synthetically Active Radiation	MJ/m2 (megajoules per square meter)
APAR	Absorbed Photo-synthetically Active Radiation	MJ/m2 (megajoules per square meter)
LUE	Light Use Efficiency factor	g/MJ (grams of carbon dioxide per megajoule of energy produced)
NDVI	Normalized Difference Vegetation Index	unitless
ε°	**T**he Maximum Possible Efficiency/Globally Uniform Maximum	g/MJ (grams per megajoule)
W	The Evaporative Fraction	unitless
ESI	Evaporative Stress Index	unitless
T_{opt}	Mean Temperature During the Month of Maximum NDVI	°C (degrees Celcius)
T_{mon}	Mean Monthly Air Temperature	°C (degrees Celcius)
T1 and T2	The Temperature Factors Related to Plant Growth Regulation (Acclimation)	unitless

Previous research has not reached the consensus regarding what value of ε° is optimal to calculate NPP using remotely sensed imagery (Potter et al., 1993). The proposed values of globally uniform maximum possible efficiency vary among the studies. Ehleringer et al. (1977) states that the upper bound for ε° is approximately 2.88 g/MJ. Potter et al. (1993) suggest that this maximum “will always be reduced by saturation in the light response of photosynthesis" (p. 819) and use the value of 0.39 g/MJ. Some studies estimate the value of $\varepsilon°$ as 2.5 g/MJ (Tripathi et al., 2010). This analysis also applies the value of 2.5 g/MJ.

The temperature scalar T2 equals 1 if $T_{mon} = T_{opt}$; T2 falls to 0.5 at approximately 10°C above and 13°C below T_{opt} (Field et al., 1995). Thus, when there is no significant variation in temperatures through the year (for example, in low-latitude geographical areas), T2 has little effect on the LUE (Field et al., 1995).

The temperature scalar T1 limits acclimation of biomass in extreme climate conditions (very low and very high temperatures) (Berry and Bjorkman, 1980). T1 is a function of T_{opt} and it equals 0.8 if $T_{opt} = 0°C$ or $T_{opt} = 40°C$, and rises parabolically to 1.0 at 20°C (Field et al., 1995). Therefore, the values of T1 vary between 0.8 and 1:

$$T1 = 0.8 + 0.02 * T_{opt} - 0.0005 * (T_{opt})^2 \qquad (8)$$

Some studies suggest that the efficiency of light utilization (LUE) is constant among the different plant types (Monteith, 1972; Heimann and Keeling, 1989), while others state the opposite (Prince, 1991; Ruimy et al., 1994). This analysis does not account for the differences in LUE between different plant types.

PAR values were obtained from the Research Data Archive managed by the National Center for Atmospheric Research. They were derived from the International Satellite Cloud Climatology Project (ISCCP) conducted by Bishop and Rossow (1991), which calculated approximate values of PAR (in W/m^2) with an accuracy of 9 W/m^2 on a daily basis by using the estimated values of atmospheric optical depth together with the values from a simplified general circulation model (GCM) (Bishop and Rossow, 1991;

Potter et al., 1993). The average daily values of PAR were converted to MJ/m^2.

NDVI values were calculated for each garden by processing remote sensing imagery in ArcGIS for Desktop Standard, version 10.4.1. Zonal Statistics as Table tool provided the sum of the pixels' NDVI values per garden. ESI values were derived from the ECOSTRESS satellite images also using ArcGIS 10.4.1. The garden-level ESI values were calculated by averaging the per-pixel values within a garden, with three to four pixels for each garden. Two NPP values were calculated in grams for each garden. First, the NPP values were calculated according to the equation (5). Second, they were multiplied by the image resolution (pixel's area = 9 square meters) to calculate the carbon sequestration per garden's area. Two two-sample t-tests were applied in R Studio to perform statistical comparison of NPP values. The first t-test determines whether there is any significant difference in carbon sequestration between two seasons. The second t-test was applied to analyze if the mean NPP of a non-growing season is less than the mean NPP of a growing season.

The analysis of the seasonal differences in carbon sequestration by community gardens focuses on the *Resource Systems (RS), Resource Units (RU), Related Ecosystems (ECO)* and *Outcomes (O)* blocks from the SES framework (Figure 10). The SES variables assigned to these blocks describe the variables from the CASA model (Table 9).

Other SES variables that affect garden's net primary productivity include:

1) RS7-1 (Consistency of activity related to resource system). It describes a consistency of gardening activities, including the regularity of scheduled workdays and the level of participation. The amount of grown food depends upon the garden members'

involvement and dedication (Petrovic et al., 2019). Decreasing participation can lead to decrease in biomass.

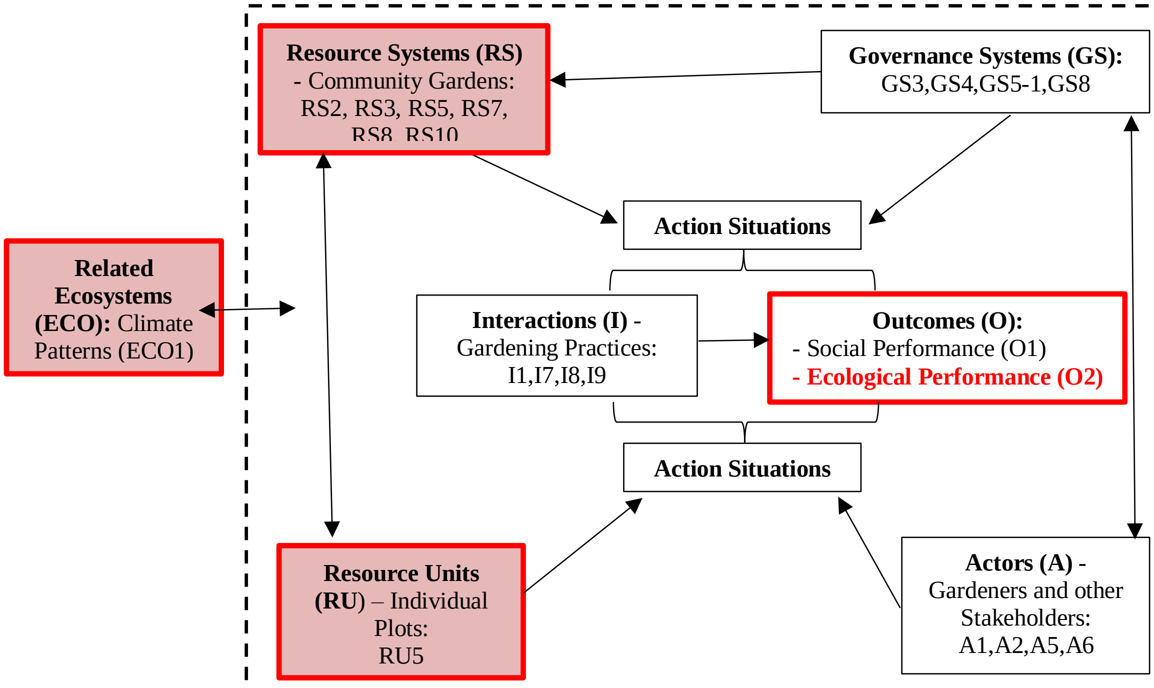


Figure 10: The SES framework to analyze the seasonal differences in carbon sequestration.

Table 9: The SES variables used to describe the CASA variables.

The SES Variable	Properties	Associated variables from the CASA model
ECO-1 Climate patterns	Includes climate characteristics that are common for all the community gardens in Austin, TX.	$T_{opt,}$ $T_{mon,,}$ PAR
RS2-1 Researcher-defined boundaries of a resource system through on-screen digitizing	Includes manually delineated boundaries of community gardens	N/A
RS3-1 Researcher-defined size of resource system	Includes gardens' areas	N/A
RS5 Productivity of system	Includes Normalized Difference Vegetation Index (NDVI)	NDVI
RS8 Storage characteristics	Estimates the amount of water stored (Evaporation Stress Index)	ESI
RU5 Number of units	Helps to manually delineate gardens' boundaries through on-screen digitizing	N/A
O2 Ecological performance measures	The seasonal differences in carbon sequestration	NPP

2) A1 (Number of relevant actors). It includes the number of gardeners and describes the level of participation and accessibility of a garden. Stable or increasing number of participants contributes to garden's productivity by providing stable or increasing amount of biomass.

3) A6 (Norms (trust-reciprocity)/social capital). It includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit – cooperation, exchange of knowledge, community building, social exchange, etc. This

variable indirectly affects ecological performance because it creates conditions that positively impact participation and involvement in gardening.

Models of governance that associated with the highest seasonal differences in NPP were revealed to determine organization and management structures that promote participation and productive gardening. Data from the key informant interviews were used to determine whether these governance approaches utilized the principles of ‘ethical action’ (Figure 2), following the same steps as the analysis of the research question 2B.

CHAPTER IV

COMMUNITY GARDENS AS DIFFERENT TYPES OF COMMONS

Scholars define commons as resources that are collectively owned and managed by communities or governments that exist for the use by and to the benefit of individuals and communities (Basu et al., 2017). Community gardens are urban green commons – physical green spaces in the city that are collectively managed (Colding and Barthel, 2013). Other studies also regard community gardens as biophysical commons (Basu et al., 2017; Gibson-Graham et al., 2013; Teig et al., 2009). The perspective taken in this study argues that they represent several kinds of commons: biophysical, cultural, social, and intellectual or knowledge commons. The Diverse Economies framework expands the meaning of a commoner beyond a human actor who uses, manages, and benefits from commons to include non-human actors (e.g., the environment), social relations (e.g., class alignments, economic systems), social movements, networks, and institutions (Gibson-Graham, 2008). The complex process of communing involves the co-existence and collaboration of people, other species, and forces of nature (Linebaugh 2008; Gibson-Graham et al., 2013). The Diverse Economies theory establishes criteria for what constitutes a common through their Commons Identi-kit (Gibson-Graham et al., 2013) (Table 10):

1. Access to property must be shared and wide,

2. Use of property must be negotiated by a community,

3. Benefit from property must be distributed to the community and possibly

beyond,

4. Care for property must be performed by community members,

5. Responsibility for property must be assumed by community members.

6. Commons can be associated with any form of ownership: private, state, or open access).

Table 10: The commons Identi-Kit (Gibson-Graham et al., 2013)

ACCESS	USE	BENEFIT	CARE	RESPONSIBILITY	PROPERTY
Shared and wide	Negotiated by a community	Widely distributed to community members (and beyond)	Performed by community members	Assumed by community members	Any form of ownership (private, state, or open access)

These criteria have been applied in this study to the community gardens of Austin, Texas to support the characterization of these spaces as commons. The following substantiates this based on the analysis of the key informants' interviews and other information obtained from the Coalition of Austin Community Gardens – a non-profit organization that facilitates the creation of community gardens in the Greater Austin Metro Area:

1. *Access* to community gardens as biophysical space is shared among community members based on the capacity (number of plots). When gardens reach their capacity, a waiting list is created. Most of community gardens in

Austin are open to general public with a few exceptions. Thus, some gardens are dedicated exclusively to senior populations (e.g., the Gus Garcia Community Garden and the Garden of Eatin' at the South Austin Senior Activity Center) and some gardens are open to residents of adjacent neighborhoods only (e.g., the Mueller Community Garden). Intellectual, cultural, and social commons associated with community gardens (e.g., environmental knowledge, gardening techniques, cultural events, and social capital) are shared among the gardeners and often extend to the non-gardening community.

2. The *use* of community gardens is negotiated between their members. In some cases, gardeners need approval of an external stakeholder (e.g., a church, a school, or the Department of Parks and Recreation), depending on land ownership and sponsorship. For instance, the Grow Together Community Garden at Gateway Church is located on church property. A representative of this garden indicated that major decisions (like installing water tanks or expanding the garden footprint) require church approval.
3. Community gardens in Austin *benefit* the immediate community (garden members), communities beyond the immediate areas, external stakeholders, urban space, and the area's ecosystems. Benefits to the immediate community include opportunities to interact with nature, provision of fresh produce, a socializing space, and fostering a sense of belonging and neighborhood support. Beyond the immediate community, many gardens donate produce to food banks and other charities:

"Two pantry beds are for the food bank drop off at Covenant United Methodist Church. We will participate in the Spread the Harvest program by maintaining a communal plot of vegetables that will be harvested for a local food bank." – Adelphi Acre Community Garden

"One of our garden plots is a community plot, and all the produce from that plot goes to an assisted living home nearby." – Cherry Creek Community Garden

"…a minimum of 10% grown produce donated to the women's shelter" – Unity Park Community Garden

"Since 2003, members have donated pounds of fresh produce to a local food bank, Micah 6. In fact, a sixth of an acre at Sunshine has been designated specifically for this purpose, and members can opt to give above and beyond from their own gardens as well. Twice a week during the summer, Sunshine members harvest, clean, and deliver somewhere between 25 and 40 pounds of produce to Micah 6. This produce will go directly to the pantry store where low-income Austin residents can stock up on fresh food." – Sunshine Community Garden

Some organizations say that their gardens beautify the neighborhood and provide social gathering space and rich landscaping. Many gardens provide environmental education programs and some even serve as outdoor learning labs for neighborhood schools.

4. Community garden members are expected to *care* for their garden's commons – biophysical spaces, social relationships, socio-ecological memory,

knowledge, and information created and shared through the activities of gardening.

"*For a few years, a set 'community night' was held on Wednesdays when gardeners would meet in garden for weekly chores and chats."* – Windsor Park Community Garden

"All plot holders are responsible for the maintenance of the common areas. This includes the shed, walkways, shade pavilion, etc. Weed control in the common gravel areas is also the responsibility of the plot holders." – Mueller Community Garden

"All members are expected to participate in maintaining the communal areas or shared plots under the direction of the Garden Steering Committee." – Anonymous Informant

5. The gardeners are assumed to take *responsibility* for the gardens as biophysical spaces. The degree of individual responsibility is determined by the garden's rules or protocols.

"[Gardeners] should meet their required monthly two (2) hours of service, give members a choice in the area or activity to which they prefer to dedicate their time."

"A minimum of 12 hours per year of volunteer time is required from all members to be spent on the communal areas." – Lamplight Community Garden

Depending on the model of governance used, often those in charge establish rules or protocols for: 1) access, 2) use, 3) care taking, 4) responsibilities, and 5) distribution of the benefits in terms of others' well-being. Gibson-Graham's criteria apply to different types of commons. For example, as social commons, community gardens include participants' interests and their relationships, and it is the common responsibility to care for them. Interviews of key informants provide evidence that community gardens represent not just the biophysical commons, but the cultural, the social, and the intellectual or knowledge commons as well.

Community Gardens as Biophysical Commons

Most community gardens in Austin identified urban agriculture as their main goal. Some gardens pointed to food production as their secondary goal. The biophysical commons resident in community gardens includes the soil, air, water, trees, flowers, and other ornamental plants. The fruit or vegetables grown for donation or distribution are also part of the biophysical commons. Community members, by growing plants, produce biomass that sequesters carbon. Vegetation indices can be used to determine the amount of biomass created to represent net primary productivity (NPP) – a community garden's ecological service. The Diverse Economies scholarship argues that different types of commons exist within the broader biophysical climate, and they interact and are interconnected. For example, a soil type can affect vegetation choice. And the amount of green space influences local and global atmospheric conditions. Biophysical commons can be affected by social and cultural commons as well. For example, gardeners can decide to plant uncommon, culturally appropriate (or culturally preferred) foods.

Community Gardens as Social Commons

Social commons include networks, conditions of social inclusivity, and social capital. Community gardens create social capital by producing natural capital in a community space that promotes congregation of people and encourages social interaction (Howard, 2004). Social capital includes social networks, solidarity, mutuality, trust, reciprocity, and the formation of a commonly held sense of place and is shared among stakeholders (Altschuler et al., 2004). In interviews, many gardeners stressed the importance of community-building and the promotion of democratic processes. Some respondents said that participating in their gardens empowered community members by the development of new skills and the development of friendships and community. The representatives of the Garden of Eatin' at the South Austin Senior Activity Center included philanthropic support among their goals. In many community gardens, alternative activities like festivals, celebrations, cooking and gardening classes and myriad social gatherings (Figure 11), often become more important than food production:

> *"Members occasionally meet together for activities outside the garden such as shopping at farmers markets and garden nurseries. Members have hosted potlucks to share dishes made with food harvested from the garden and to discuss upcoming projects and activities. Occasionally we will go on field trips to broaden our experience of nature. With such proximity to other community activities, there are often people in the area that visit the garden out of curiosity*."
> – the Rollingwood Community Education Garden

> *"[We] provide the opportunity to participate in the creation of and be a part of a*

"good community" while learning how to better use the planet as they enjoy and care for themselves." - Anonymous Informant

"*In addition to providing our gardeners and their families with a reliable source of fresh, nutritious and affordable food, the garden has become a site of cooperation, collaboration, celebration, and developing friendships between diverse neighbors."* – Festival Beach Community Garden

"We create a sense of community in our neighborhood" – Lamplight Community Garden

"A secondary goal is to connect and grow socially and spiritually with our community and our fellow members at Gateway Church" – Grow Together Community Garden

Figure 11: A social gathering at the Cherry Creek Community Garden

The social commons also strives for equal opportunities and equal rights to overcome social exclusion of the poor and other groups defined by sex, age, or physical infirmity (Figure 11). Community gardens achieve this by creating welcoming atmospheres that provide assistance and accessibility. For example, the Lamplight Community garden has *"a dedicated area for a children's garden."* And Sunshine Community Garden works to improve access for people with disabilities:

> *"Sunshine gardeners came together this year to build some great raised beds to improve access and broaden accessibility to the garden and expand our membership. Three raised beds were recently constructed that allow access for people in wheelchairs…There is room to maneuver a wheelchair around them and the plots are adjacent to our parking area for easy access."*

Self-provisioning offered by community gardening opposes "the dominant reading of a consumer- and market-driven society and challenges representations of the unilinear trajectory of capitalist development." (Gibson-Graham, 2008, p. 625). In the scholarship focused on urban political ecology and diverse economies, economy is part of the natural system, rather than being 'supernatural' (Jacobs, 2000). As other natural systems, community economies thrive when there is diversity, self-provisioning, and co-development (Jacobs, 2000). Diversity ensures social inclusion of the array of ethnic, gender, and age groups. In the pursue of social inclusion, some gardens in Austin offer affordability, and opportunities for elderly and intergenerational interaction and the appreciation of personal and cultural differences. Many ethnic groups (Asian, Black, Hispanic, and Indian) participate in community gardening in Austin. The Unity Community Garden estimated that about 40 percent of their gardeners are White, and the balance are Indian Americans and Asian Americans. Three community gardens collaborate with the Multicultural Refugee Coalition (MRC) to increase racial and ethnic diversity. Some gardens target certain minority groups. The Asian American Resource Center Community garden is open to seniors over 60 and most are Asian Americans. However, most gardens have more age diversity than ethnic diversity:

> *"We have a fairly even age distribution with members ranging in age from 70's to teenagers. Ethnically speaking, the majority are Caucasian".* – Labyrinth Community Garden

> *"The majority of the garden members are white, although there are some members who are Latinx and Asian."* – Cheery Creek Community Garden

> *"Our youngest member came to his first farm day at 1 month old, and I believe our oldest member said she is 83"* – PEAS Community Farm

> *"We don't formally track demographics in our garden but 27 of our plot owners are women, 20 are men. We have two African American plot owners, four Hispanic American plot owners, and four Asian American plot owners*". – Patterson Community Garden

> *"Our gardeners are from 21 to 79 years old*" – Deep Eddy Community Garden

Community gardens establish social networks through the activities of gardening: planting, cleaning, composting, recycling, decision-making, fundraising, environmental education, sharing produce, and cultural events (Glover 2004). These social networks often extend beyond the garden:

"Our garden brings community members to the campus and offers potential for building partnerships with local businesses and relationships with people who will care about the school. Exposes students to career opportunities in the local food system". – PEAS Community Farm

"For years we had a beautiful relationship with the pastor of Latino Ministries at the church across the street and a group came to the farm monthly to help out." - Anonymous Informant

"Top-down" models of governance expand social networks by involvement of external organizations. On the other hand, "bottom-up" models create social capital by including community members in decision-making and extending their authority to create rules and shape norms (Rydin and Pennington, 2000).

Community Gardens as Intellectual Commons

Scholars often discuss the contributions of community gardens to communities' collective memories where the experiences of living pasts are stored and which determine the behavioral patterns of communities (Middleton and Edwards, 1990; Coser, 1992; Gongaware, 2003; Barthel et al., 2010). Collective memory consists of individual memories shared through social interactions and common languages, symbols, events, and cultural contexts (Barthel et al., 2010).

In community gardens, social-ecological memory involves the collection of ecological information through observation, interpretation, and analysis (Barthel et al., 2010). It also includes information regarding the effective organization, management, and governance of community gardens. This information is the intellectual or knowledge commons that is created, shared, retained, and enacted through social relations and networks created in the community gardens (Figure 12). Intellectual commons grow when they are shared and added to; when community gardens seek for advice and expertise of external professionals or more experienced gardeners to teach new members, for example. Productivity increases as gardeners' knowledge about gardening expands:

> *"A very important purpose of the Rollingwood Community Education Garden is to provide educational support on a wide range of gardening and environmental topics. This includes but is not limited to the following: […] Guidelines on when and how to plant and harvest various plants. How to tend during the growing season. Sustainability principles via composting, rainwater collection, and recycling. RWCEG members provide garden tours to any interested visitors. If members are present at the garden, they usually pause their activity to invite visitors for a guided tour. Most folks are casual on-lookers, but some really want to learn more to implement some of our gardening techniques at their residence.*"- the Rollingwood Community Education Garden

> *"[Our] secondary goal is to share and teach others organic gardening concepts and principles."* – Grow Together Community Garden

> *"[Goal is] education (a special stewardship team dedicated to educating our gardeners and members of the community interested in gardening)."* - South Austin Community Garden

> *"[We] provide space to develop 'community' for less experienced gardeners to learn from more experienced gardeners"* - Windsor Park Community Garden

Figure 12: A group of children learning about gardening at the Rollingwood Community Education Garden

> *"Members get hands*-on *experience with organic gardening in the local environment, share information, harvest healthy delicious vegetables, and enjoy each other's company."* - Anonymous Informant

Knowledge commons created by community gardens often extend beyond their borders and involve different scales of networking. For example, one of several goals of the PEAS Community Garden is to provide an outdoor-learning lab for Cunningham Elementary students:

> "*Lessons are easily aligned with state curriculum standards for science, economics, and health… This year we also provided lessons to all of 2nd* and *3rd grade (~150 students) on a weekly basis. Next year we will provide to all grade levels ~400 students."*

"Community experts are invited to present hands-on, experiential classes to the community on a variety of topics such as gardening, composting, cooking, canning, and pickling. Classes are accessible to community members of all ages."

"[We] hosted educational films for the neighborhood that are presented at a nearby pavilion in the adjoining park. These films encourage use of organic and local food sources (Farm Inc), and methods of sustainable farming". - the Rollingwood Community Education Garden

"[We] provide opportunities for youth groups to take part in 'hands-on' learning about sustainable food, healthy lifestyles, and nutrition". - the Adelphi Acre Community Garden

Community Gardens as Cultural Commons

Social relations among stakeholders and gardeners' relationships with nature are materialized through reification. Reification creates cultural commons and depends on the participation of members of community gardens in gardening activities as well as in collective meetings, rituals, and other social gatherings (Barthel et al., 2010). Gardeners collectively decide the plants to grow on the common plots, how to better distribute functioning zones (e.g. composting area, picnic zone, utilities, kids play area, greenhouse, etc.), and how to express their sense of community and appreciation through physical objects (Figures 13-15). For example, members of the Community Gardens at Gus Garcia Recreation Center planted a yaupon tree in 2019 to honor Austin's first Hispanic mayor Gustavo "Gus" Garcia and his public service. This tree is now a symbol to current and future generations of gardeners. Some physical objects reflect gardeners' missions and reflect their attitudes towards nature:

> *"The exterior of the garden fence includes signage to summarize the principles of organic sourcing, square-foot-gardening techniques, composting, and rain-water collection."* – says the manager of the Rollingwood Community Education Garden.

Gardens use material objects to distinguish themselves from others and attract to certain groups of people. For example, Labyrinth Community Garden features a meditation labyrinth (Figure 16), others use objects to express religious beliefs and creativity (Figures 17). Cultural commons include cultural exchange – for example, the Festival Beach Community Garden collaborates with MRC and provides gardening space for Bhutanese and Burundian refugees to produce familiar vegetables and social space at solstice potlucks and other gatherings to share their cultures (Figure 18). The Asian American Resource Center Program Garden says that the vegetables they grow are primarily Asian vegetables because most of their gardeners are Asian Americans.

Figure 13: A garden sign collectively created by the gardeners at the Sunshine Community Garden

Figure 14: A creative art sign at the Festival Beach Community Garden

Figure 15: Collectively created art objects at the St. David's Foundation Community Garden

Figure 16: A meditation labyrinth at the Labyrinth Community Garden

Figure 17: A sign at the Grow Together Garden at Gateway Church expressing members' religious values

Figure 18: A member of the Multicultural Refugee Coalition during a cultural event at the Festival Beach Community Garden

Community gardens also represent community economies that advocate for ethical action as they synthesize the gardeners, their communities, and the natural world. Community economy brings together people with different backgrounds, values, and expectations whose goals are guided by principles of ethical action (Gibson-Graham, 2006). According to Gibson-Graham (2006, 2013), successful governance of commons is built upon these principles. The principles of ethical action proposed by the Diverse Economies framework (Figure 2) have been revealed in community gardens in general (as reported in the scholarly literature), and are found in Austin's community gardens in particular (as revealed in the key-informant interviews) (Table 11).

Table 11: Principles of 'ethical action' presented in the community gardens in Austin

Principle	Application in the community garden	Example from key-informant interviews
Surviving together well and equitably	As social commons, community gardens advocate for social inclusion and community building and create social capital that includes solidarity, mutuality, sense of place, social networks, trust, and reciprocity.	Lamplight Community garden: *"[We] provide local gardeners with a reliable source of fresh, nutritious, organic, and affordable food.* *Anonymous Informant:* *[We] create a gathering space that brings together diverse neighbors to encourage cooperation, collaboration and friendship.*"
Distributing surplus to enrich social and environmental health	Many community gardens in Austin donate their produce to food banks and other charities. Community gardens also provide multiple ecological services (biodiversity, microclimate regulation, filtration of atmospheric particulates, rainwater retention, noise attenuation, carbon sequestration).	*"The Good Soil Community Garden seeks to teach the church how to work the land for food while feeding the homeless and lower income families in East Austin."* A very few number of key-informants have indicated ecological benefits in their answers.
Encountering others in ways that support their well-being as well as ours	Community gardens in Austin aim to generate collective food security by donating their produce to food banks and other charities and promote a healthy lifestyle.	"*One of our garden plots is a community plot, and all the produce from that plot goes to an assisted living home nearby*" – Cherry Creek Community Garden The PEAS Community Farm *"[…] creates a place of visual beauty and inspiration, and provides healthy lifestyle activities*

		and an outdoor space for positive relationships to develop”
Consuming sustainably Caring for – maintaining, replenishing, and growing – our natural and cultural commons	City of Austin defines community garden as “operated in a manner that includes water conservation, and in the case of eligible city land includes composting, non-polluting, and integrated pest management practices that promote a sustainable garden, and is cultivated solely for the production of organic produce”	Rollingwood Community Garden provides “*educational support on a sustainability principles via composting, rainwater collection, and recycling*”
Investing our wealth in future generations so that they can live well	Many community gardens in Austin serves as educational centers for children and adults and promote healthy lifestyle	The Adelphi Acre Community Garden: *“[We] provide opportunities for youth groups to take part in ‘hands-on’ learning about sustainable food, healthy lifestyles, and nutrition.”*

Interviews with key-informants showed that some community gardens in Austin follow all six principles of successful commons governance, while others incorporate only some of them. The degree of use of principles of ethical action depends on the garden’s purposes and values, socioeconomic profile of its members, and its form of governance. The next chapter investigates the models of governance utilized by community gardens in Austin and investigates aspects of gardens’ organization and management that reflect gardens’ commitment to the principles of ethical action.

CHAPTER V

GOVERNANCE MODELS USED IN AUSTIN'S COMMUNITY GARDENS

Research Question 1: What approaches to governance do Austin, Texas' community gardens use?

There are six types of community projects' governance models, five come from McGlone et al. (1999): "1) 'top-down': projects managed and run by professionals (p. 17), 2) 'top-down': projects managed by professionals but run by paid workers/volunteers (p. 18), 3) 'bottom-up': projects managed and run by local communities with the help of paid workers and professionals (p.18), 4) 'bottom-up': projects managed and run by local communities with informal support from a professional (p. 19), 5) 'bottom-up': projects managed and run by local communities (p. 19)." A sixth is suggested by Fox-Kämper et al. (2018, p. 62): 'bottom-up' with political and/or administrative support, which includes funding, land tenure, and advising. Top-down governance typically includes a local government and non-governmental professionals, while bottom-up governance involves community members leading decision making (McGlone et al., 1999). In practice, governance often blends these models (Nettle, 2014); government agencies and gardeners share the power (Table 12).

To determine governance approaches utilized by gardens, it is important to understand the distribution of power among the participants of the garden, such as: who takes the leadership (A5), who participates in the garden's organization, including decision-making and management (GS3), who implements the rules (GS5-1), and who owns the garden's land (GS4). Power dynamics are embedded in and analyzed through

Table 12: The description of the types of the governance of community gardens (McGlone et al., 1999)

Type of Governance	Description
'Top-down': projects managed and run by professionals	Governmental or non-profit organizations manage and operate a garden entirely, including decision-making. Management committees have no local community representation.
'Top-down': projects managed by professionals but run by paid workers/volunteers	Governmental or non-profit organizations manage a garden, including decision-making. They hire workers or seek for volunteers to run a garden. "Gardens planned, established, or managed by paid professionals with limited community involvement" (Fox-Kämper et al.: 2018, p. 60).
'Bottom-up': projects managed and run by local communities with the help of paid workers and professionals	Community members manage and operate a garden with the help of hired workers and professionals. Decision-making is run by both local communities and paid professionals. Professional help is usually stronger during the planning and establishing stages (Fox-Kämper et al., 2018)
'Bottom-up': projects managed and run by local communities with informal support from a professional	Community members manage and operate a garden with the unpaid (unstructured) help of professional organizations, including NPOs. Professionals can offer advice, provide funding, and participate in some decision-making
'Bottom-up': projects managed and run by local communities	Community members manage and run a garden exclusively, including decision-making. Sometimes gardens can obtain external support on their own terms, including advise and funding. Usually there is no consistent funding
'Bottom-up' with political and/or administrative support, which includes funding, land tenure, and advising	Community members manage and operate a garden with the help of governmental organizations. Decision-making is run by local communities while the government provides funding, land tenure and/or advice

various activities related to community gardening, such as planting and harvesting (I1), activities that do not involve food production, such as self-governance, garden's maintenance, formal and informal environmental education and leisure activities (I7), networking (I8) and monitoring (I9). These variables serve as codes for a deductive coding process that analyses interviews with key informants.

The SES variable A5 (Leadership/entrepreneurship) describes a model of governance used by gardens. It involves leadership in both management and operation. Depending upon who occupies the leadership positions, governance approaches can represent ‘top-down’ or ‘bottom-up’ management structures (Table 13). This study uses a typology that includes two types of ‘top-down’ governance and four types of ‘bottom-up’ governance. Other SES variables differentiate among these types. Thus, if gardens with ‘top-down’ governance have volunteers or paid workers in their network structure (GS3), they represent the second category in McGlone’s typology (Table 13). ‘Bottom-up’ gardens that cooperate with the local government represent governance style proposed by Fox-Kämper et al. (2018) (Table 13). The SES variable GS3 (Network structure) reflects the scale at which a garden operates. It shows that community gardens in Austin are spatially embedded in socioeconomic and political settings. Network structures are determined through the analysis of networking activities (I8 variable), like securing funding, promotion, donations, environmental education, distribution of surplus, etc. For example, many gardens donate their produce to local food banks and charities. Gardens’ networks also include external organizations that provide financial support and information. For instance, the St. David’s Foundation Community Garden receives sponsorship and advice from the economic sector:

> *“We work closely with the Sustainable Food Center as our fiscal sponsor. We use a google group to communicate to gardeners on business and priorities related to*

the garden." - the St. David's Foundation Community Garden

Some gardens collaborate with schools to extend their intellectual commons beyond the garden's community to a larger scale. For example, the PEAS School and Community Farm and Urban Orchard is used as an outdoor-learning lab for the Cunningham Elementary School students and provides lessons approximately to 150 students on a weekly basis. The garden's management reflects its network structure. For instance, the organizational structure of the Adelphi Acre Community Garden includes several stewardship teams: OutReach Team, Infrastructure Team, Education Team, Compost Team, Donation Team, Orchard Team, Flora Team, Oak Grove Team, Marketing and Events Team. Each team performs specific tasks and interacts with certain groups of actors, for example, the OutReach Team "*develops volunteer relationships with schools, businesses, organizations and so on, taking the garden out to the wider community and vice versa*."; the Marketing and Events Team is "*responsible for promoting the garden to the wider community and for organizing potlucks, community events, festivals, plant sales, and other social events. [It] sells garden-branded t-shirts and water bottles*." (the Adelphi Acre Community Garden). In this example, a community garden creates networks through the distribution of its social and cultural commons. Many other gardens use stewardship teams to divide different tasks among the gardeners for more effective performance.

Most of the community gardens in Austin are located on land belonging to the City of Austin. Some gardens use land belonging to churches or schools. For most community gardens in Austin, these property rights (GS4 variable) do not affect the management and the decision-making except in the case of church property. For example, the Unity Community Garden has a church liaison who the gardeners consult for decision making. Another example is from the Hyde Park Community Garden:

> *"Because the garden is on church land but there are no longer church members involved, the garden has an MOU with the church stating that the gardeners can make most decisions but must seek approval from the minister for purchases of over $100 from the garden account and should seek approval from the church board about changes to the space (new additions, planting trees, etc.)."*

This study proposes a second-tier SES variable – GS5-1 (Rules and protocols) – which establishes the steps for implementing rules and protocols and the forms that can they take – formal or informal. It determines who is in charge of organization and management. Rules and protocols determine the criteria for membership and participation, levels of gardeners' individual responsibilities, behavioral norms, participants' rights, and obligations. Thus, the rules regulate not only the use of gardens' biophysical space, but also the related social, cultural, and intellectual commons. For example, Lamplight Community Garden Membership Rules establish social behavior that promotes positive social capital: *"There should be no harassment, threats, verbal abuse, or acts of violence by any person against any other person*." This research also investigates whether rules and protocols of Austin gardens reflect the principles of ethical action. Monitoring and sanctioning rules in place (GS8 variable) also indicate the distribution of power among the gardeners. The presence of a system carried out by community members for monitoring members' behavior is one of the principles of successful governance of commons described by the literature. Lack of communication, monitoring, and sanctioning affects the productivity of gardening. For example, the

Adelphi Acre Community Garden creates a monitoring system by maintaining an up-to-date digital record of hours served by each stewardship team which can be viewed on their website. After assigning these SES variables to key informants' answers, the flow chart (Figure 8) was used to determine the model of governance. The analysis revealed three governance approaches adopted by community gardens in Austin (Table 13).

Table 13: Models of governance used by community gardens in Austin.

	Models of Governance					
	'Top-down': projects managed and run by professionals	'Top-down': projects managed by professionals but run by paid workers/volunteers	'Bottom-up': projects managed and run by local communities with the help of paid workers and professionals	'Bottom-up': projects managed and run by local communities with informal support from a professional	'Bottom-up' with political and/or administrative support, which includes funding, land tenure, and advising	'Bottom-up': projects managed and run by local communities
Number of Community Gardens	0	8	0	13	0	5

Most gardens follow the governance approach: *'bottom-up': projects managed and run by local communities with informal support from a professional*. Many gardens who follow this model collaborate with the Sustainable Food Center (SFC). It is a non-profit organization whose goal is to "increase the amount of local food consumed by residents in Central Texas by 2035 and to cultivate a just and regenerative food system so people and the environment can thrive" (the SFC, 2019). The SFC plays an important role because serves as a sponsor and adviser to many Austin's community gardens:

"The SFC helps the garden by carrying an insurance policy, holding the garden's

funds, paying the City of Austin water bill, and providing a platform to collect dues from gardeners." – Cherry Creek Community Garden

"*Checks on City of Austin water bills are paid by SFC*" - the South Austin Community Gardens

"*Sustainable Food Center provides plants/mulch/seeds/fertilizer*" – Windsor Park Community Garden

Other external organizations that sponsor or help community gardens in Austin include Sprouts Healthy Communities Foundation, the Rollingwood Women's Club, St David's Foundation, Austin Park Foundation, public schools, religious institutions, and businesses. For example, a key informant from the Unity Community Garden stated:

"We have had companies like IBM and Dell donate, we have also had lots of volunteer time donations from groups like Concordia High School, Sema, etc."

Some gardens received financial support from the local and state governmental organizations like the Austin Parks and Recreation Department, the City of Austin's Office of Sustainability, the Texas Department of Agriculture, and the Texas Farm Bureau. These gardens are managed by professionals and employ a 'top-down' model of governance. This can indicate that professional organizations have better access to the local government and able to reach for governmental support easier than 'bottom-up', community-managed gardens. Another explanation can be the presence of the Sustainable Food Center and other non-profit organizations that sponsor and advise community gardens with 'bottom-up' governance, so they do not need to seek governmental support.

This study reveals that no community gardens in Austin hire workers to run the garden or professionals for organization and management. Gardens with ‘top-down’ governance structures are run by volunteers. Schools, non-profit organizations, churches, and businesses assist ‘bottom-up’ community gardens voluntarily. The organization and the management determine the efficacy of collective action performed by gardeners; this can be evaluated by both the amount of biomass produced and the sense of accomplishment and satisfaction expressed by gardens’ members.

Members’ Perceptions of the Success of Community Gardens

Research Question 2: How do the members of community gardens evaluate the success of the gardens?

The last question on the questionnaire (Appendix A) asked community gardens’ representatives to indicate their perceptions of the success of their community garden by checking the appropriate Likert-scale value ranging from ‘unsuccessful’ to ‘very successful’. This question was asked to evaluate the social outcomes of community gardening. Social outcomes in this study are gardeners’ perceptions of their success expressed as levels of satisfaction and feelings of accomplishment. In the literature, community gardening is often seen as “a socialistic enterprise reflecting communitarian values” (Guitart et al., 2012, p 369). Social benefits of a community garden are regarded as the satisfaction of the garden experienced by its participants. According to the Diverse Economies Framework, the perceptions of success reflect community’s values and priorities that may differ among gardens. The SES variables that serve to understand the gardeners’ perceptions include (Table 7):

1) RS7-1 (Consistency of activity related to the resource system). It describes a consistency of gardening activities, including the regularity of scheduled workdays and the level of participation. The garden's success depends upon the garden members' involvement and dedication (Petrovic et al., 2019). A consistent operation and stable or increasing involvement may indicate that a garden fulfills community's expectations and needs.

2) RS10-1 (The longevity of the resource system). It describes how long a garden has been operating. Long-existing gardens are likely to possess higher levels of experience.

3) RS3-1 (Researcher-defined size of resource system). It shows the area of the garden, which affects the garden's functionality.

4) A1 (Number of relevant actors). It includes the number of gardeners and describes the level of participation and accessibility of a garden. Researchers argue that a value of a community garden can be measured by the right to its access and use (Foster and Iaione, 2016). Stable or increasing number of participants reflects the garden's value to the community.

5) A2 (Socioeconomic attributes). It includes socioeconomic and demographic characteristics of the gardeners. Understanding socioeconomic attributes helps to explain perceptions of the success.

6) A5 (Leadership/entrepreneurship) – describes a model of governance. Management practices and institutional rules determines the strength of the created social capital (Andersson et al., 2007).

7) A6 (Norms (trust-reciprocity)/social capital). It includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit – cooperation, exchange of knowledge, community building, social exchange, etc.

8) O1 (Social performance measures) - gardeners' perceptions of the success of their community garden. Social outcomes help to understand how the gardeners envision their community gardens in terms of their goals, barriers, and success.

These variables contribute to the sense of accomplishment, or the level of satisfaction (social performance measures) derived from activities related to community gardening: harvesting (I1), self-organizing activities (I7), and networking activities (I8) (Table 7). They were used to get a deeper insight into gardeners' evaluation of their success.

Four gardens indicated their level of success as Successful, but with many issues/problems (Table 14). These gardens operate consistently throughout the year and have regular scheduled meetings to perform gardening chores that require collective action and to discuss organizational issues. In terms of the longevity, two of these gardens were established in 2012, and the other two – in 2003 and 2005, respectively. Interestingly, the older gardens have less participants than the newer gardens. Thus, the St. David's Foundation Community Garden was established in 2012 and has 40 members,

Table 14: Community gardens' perceptions of their success

	Please indicate your perception of the success (your personal measure of success) of your community garden by checking the appropriate box on the scale below				
	Unsuccessful	Unsuccessful, but has a potential for improvement	Successful, but with many issues/problems	Successful, but with a few issues/problems	Very successful
Number of Community Gardens	0	0	4	10	12

while the Windsor Park Community Garden was established in 2005 and has only 7 members. Both gardens employ *'bottom-up': projects managed and run by local communities with informal support from a professional* governance approach and they seem to struggle with understanding the best management techniques and policies to govern the garden. The other two gardens are non-profit organization that use volunteers to run the gardens. The common problem for all four gardens is low participation when it comes to common duties such as taking care of garden's common areas.

Ten gardens indicated their levels of success as 'Successful, but with a few issues/problems'. Most of the gardens (twelve) indicated their levels of success were 'Very Successful' (Table 14). No key informants considered their community gardens to be 'Unsuccessful' or 'Unsuccessful, but with a potential for improvement.'

The SES variable RS7-1 (Consistency of activity related to resource system) describes a consistency of gardening activities: regularity of workdays, level of participation (Figure 19). All gardens have established weekly or monthly workdays when gardeners come to take care of the communal plots and other common areas and perform tasks, such as weeding, mulching, planting, watering, fertilizing, digging holes, planting trees, composting, etc. Most of the gardens whose representatives were interviewed set a required amount of time, monthly or annually, which volunteers must meet. Many gardens also establish days for decision-making meetings.

The most successful gardens have consistent (or stable) levels of participation (Figure 20). Taking care of the garden's biophysical space often results in social, cultural and intellectual capitals:

> *"We have monthly workdays to encourage a sense of community and to provide an educational opportunity on sustainable gardening practices*" - Patterson Park Community Garden

The Adelphi Acre Community Garden's stewardship teams serve to strengthen the sense of community, better manage the monthly workdays and various administrative tasks:

> *"Participation in stewardship teams is mandatory. Individual teams will help members to meet their required monthly two (2) hours of service, give members a choice in the area or activity to which they prefer to dedicate their time, enable members to connect with each other, and eases the burden of scheduling around everyone's availability."*

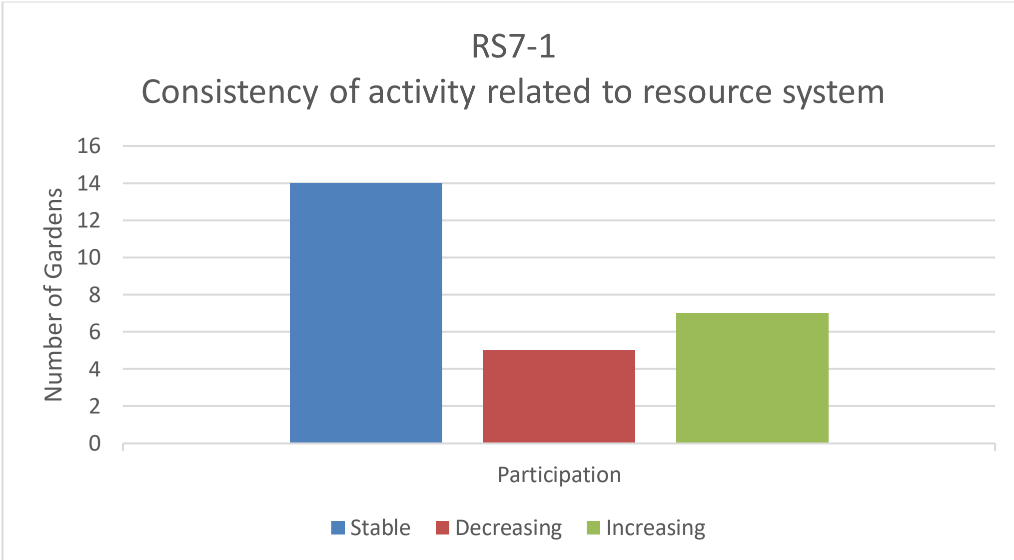


Figure 19: Levels of participation in community gardens in Austin

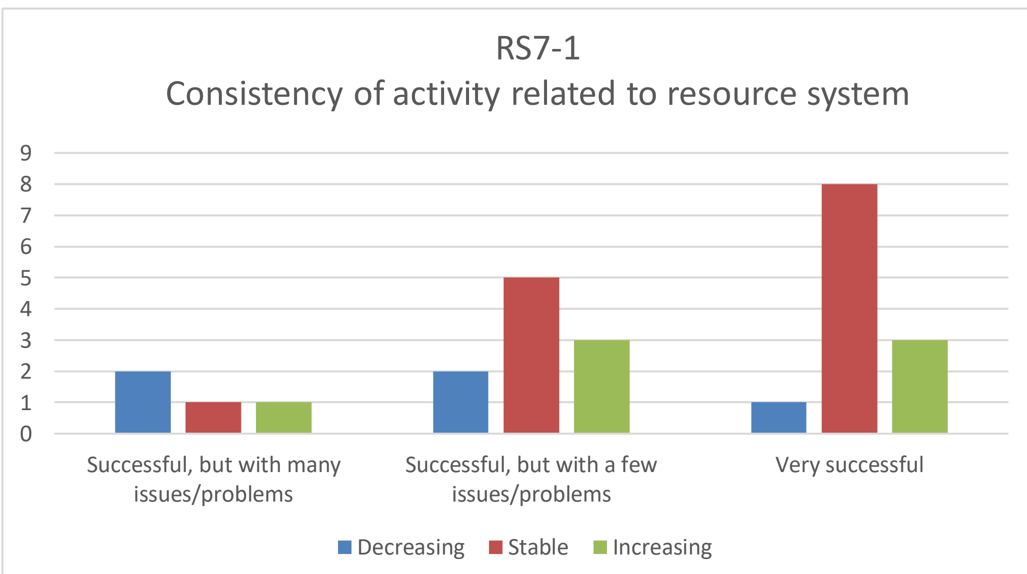


Figure 20: Level of participation in community gardens by the perception of success

However, not all gardens formally document these requirements in their rules or protocols. More than half of the gardens interviewed experienced issues with participation in group activities. Though only 5 out of 26 gardens have a declining participation, most gardens struggle with members' participation in collective duties like general garden maintenance. This may affect the consistency of social interactions, and by extension social capital. Gardens that perceive themselves to be “successful, but with a few issues/problems” seem to struggle with organization and management the most. Some of the gardens from the ‘very successful’ category encounter a different problem: their capacities cannot accommodate the number of people who want to join the garden, and they have long waiting lists. Thus, Clarksville Community Garden gives priority to people living nearer the garden.

The level of participation affects a garden’s longevity (and is also affected by it). The SES variable RS10-1 (The longevity of resource system) is how long a garden has existed (Figure 21). The four oldest gardens in the study area were established before 1995. Most of the gardens were founded between 2011-2015, after 2006 when the community gardening movement in Austin gained momentum (Figure 21). This timing suggests that many community gardens in American urban areas emerged as a response to the 2008 financial crises. They also point to the place-specific network system in Austin and that created the conditions from which community gardens emerged. In the second half of the 20th Century, many non-profit organizations were formed to help community members start a garden (Lawson, 2005). In Austin, the main non-profit organization that provides an assistance and sponsorship to community gardens is Sustainable Food Center (SFC). It was originally a community garden project that became an independent non-profit organization in 1987 and got its current name in 1993 (Sustainable Food Center, 2020).

In 2005-2015 the SFC expanded and launched several local food movements:

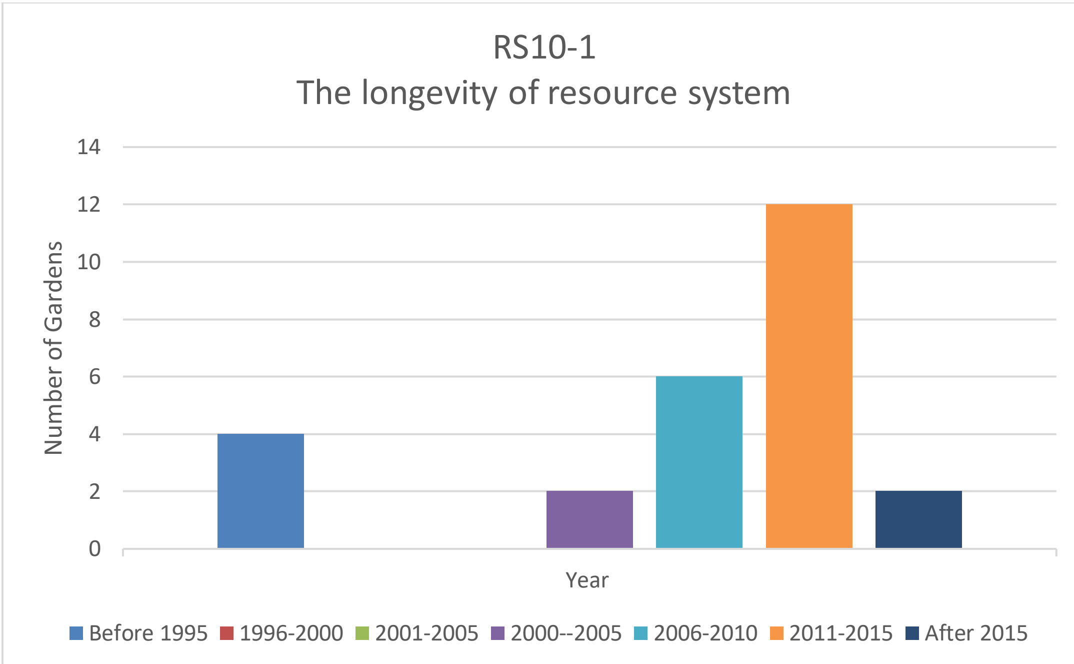


Figure 21: The longevity of community gardens based on the year founded.

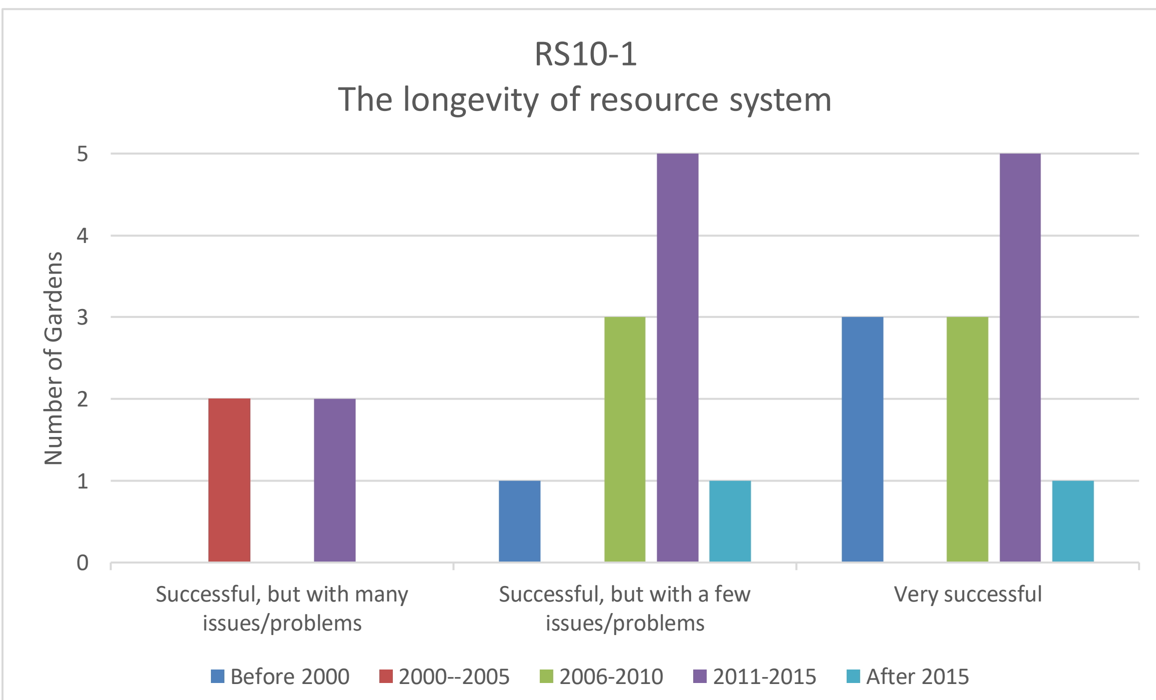


Figure 22: The perception of success organized by year founded.

a) SFC Farmers' Market at Sunset Valley,

b) a Farm to School food systems education project "Sprouting Healthy Kids", that aims to provide fresh produce to Austin-area low-income middle schools and educate children about healthy eating behaviors through gardening, and

c) a Farm-to-Work program, that aims to provide fresh local produce to governmental and corporate employees via weekly delivery to worksites.

Most of the gardens that consider themselves 'very successful' were established between 2006-2015 (Figure 22). The oldest gardens in Austin (founded in 1978, 1979 and 1981) are perceived to be the most successful. These three gardens are also among the most populated gardens.

The SES variable A1 (Number of relevant actors) shows how many members a garden has and investigates the garden's capacity and the level of community involvement (Figure 23). About one-third of the interview gardens have 21-30 participants. There are five community gardens with more than 50 gardeners; four of them indicated the highest level of perceived success (Figure 24). The interviews with key-informants shows that often participation in community gardens depends on the institutional ties (to a school, a church, a non-profit organization) as well as informal social connections (to a family or a neighborhood). For example, a President of the Rollingwood Community Education Garden described how he became a member of this garden:

> "*I joined RWCEG largely to support an interest my son had in gardening when he was in grade school.*"

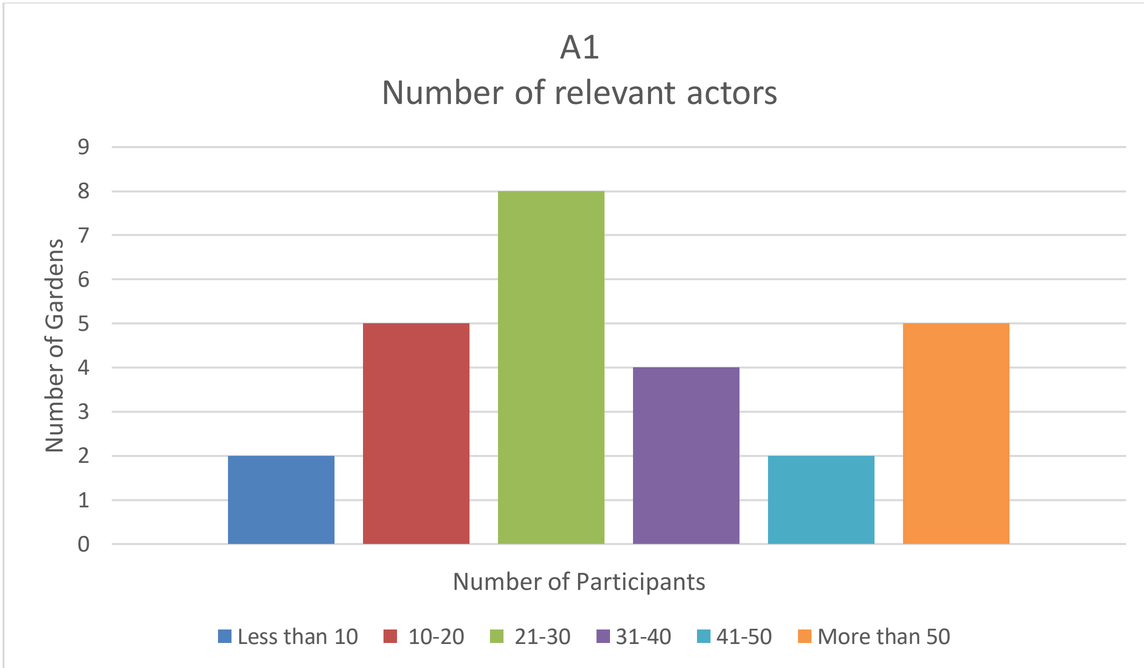


Figure 23: Community gardens by the number of participants.

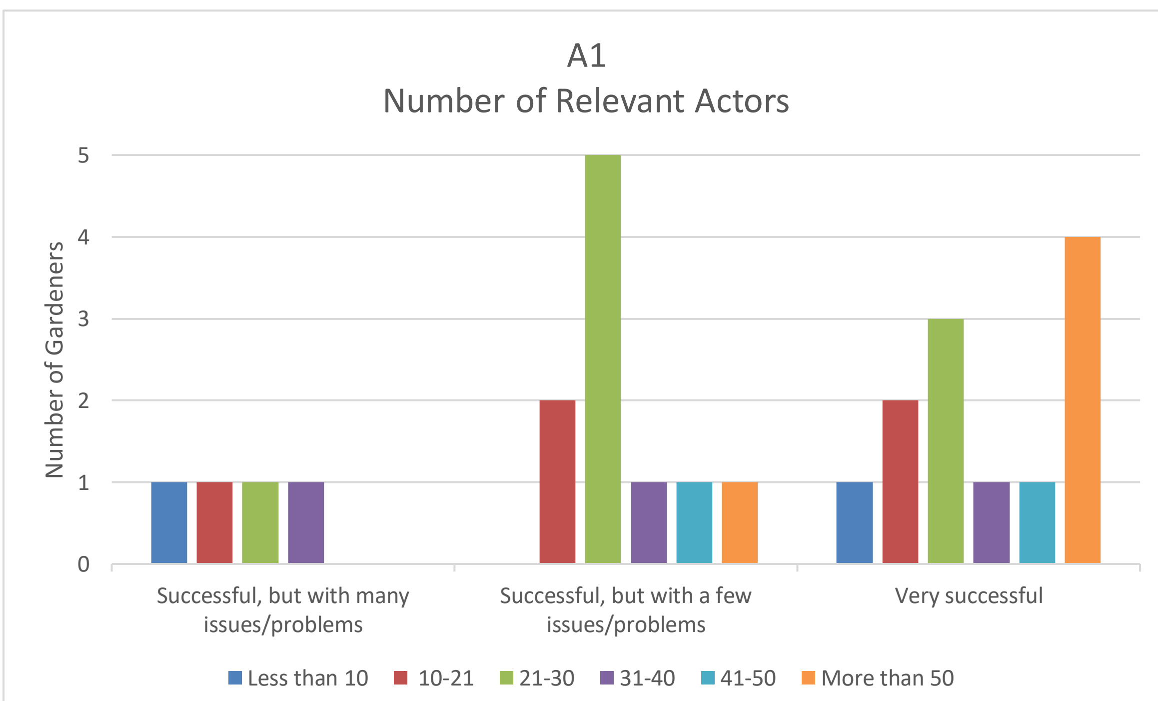


Figure 24: The number of participants by the perception of success.

The SES variable A2 (Socioeconomic attributes) includes socio-economic and demographic characteristics of participants, such as income, age, gender, and race and ethnicity. These characteristics affect the gardeners' goals, motivations, values and perceptions of success. The most common goals and purposes of community gardens in Austin match those described by the literature and include the following:

1. To provide a place for local communities to grow organic food,

2. To provide fresh food for low-income residents,

3. Community building and social exchange, including connections to the larger community outside the garden, and

4. Environmental education and promotion of sustainable gardening practices.

Some gardens also indicated very specific goals, for example the Cherry Creek Community Garden was created to utilize the land that otherwise would be unused:

> *"Our community garden was originally planned as a result of a portion of the neighborhood's houses being razed due to flooding. The neighborhood voted to create a community garden to prevent the land lying fallow."*

Other specific purposes include facilitating a connection to the Earth, promoting Christian values and principles, glorifying God (Grow Together Community Garden at Gateway Church, Good Soil Community Garden), assisting the elderly, teaching sustainability to youth groups, beautifying the neighborhood, increasing the value of property (Mueller Community Garden), and creating wildlife habitats (Lamplight Community Garden, Festival Beach Community Garden).

Gardeners' perceptions of their success and their levels of satisfaction depend on whether a garden serves its purposes, achieves its goals, has stable or growing participation, has sufficient funding, etc. Socio-economic and demographic attributes help to understand why communities have certain values. This analysis did not determine any economic attributes of the gardeners in Austin. The key-informants indicated that gardens do not keep records of the income level or other economic characteristics of their members. The ethnic composition includes people of White, Asian, Black, Hispanic or Latino, and Indian ancestry. The analysis of key-informant interviews did not reveal any associations between the perceptions of success and ethnic composition or age. Every garden has representatives of at least one minority ethnic group, but most of the gardeners are still predominantly White and of all ages. A few exceptions include:

1. Members of the Asian American Resource Center Program Garden are seniors over 60 years old and mostly Asians. Another two gardens that are dedicated to senior population are the Garden of Eatin' at the South Austin Senior Activity Center (members are 55 and over years old) and the Serenity Senior Garden that is a part of Gus Garcia Community Garden. In their purpose statements they emphasize their goal to improve the lives of older adults through education, volunteerism and philanthropic support. All these three gardens have a 'top-down' governance structure.

2. Hyde Park Community Garden is run by young people between 25-40 years old, some of them are in post-graduate programs at the University of Texas. This garden has a governance model *'bottom-up': projects managed and run by local communities,* which has the highest level of autonomy hold by community

members.

3. Three community gardens collaborate with the Multicultural Refugee Coalition (MRC) and have gardeners from Bhutan and Burundi.

The SES variable A5 (leadership/entrepreneurship) helps to determine who takes the leadership in the organization and management – community members, governmental or professional organizations. In most of ‘very successful’ community gardens in Austin (75%), the leadership is taken by community members.

The SES variable A6 (Norms (trust-reciprocity)/social capital) includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit. Community gardens as social commons include relationships and activities that aim to achieve trust, solidarity, sense of place, social inclusion, build networks, and help others flourish. Regardless their perceptions of success, all community gardens indicated positive social capital as one of their goals:

> *“[We] create a gathering space that brings together diverse neighbors to encourage cooperation, collaboration and friendship*.” - Anonymous Informant

> *“Building community through participation and empowerment of community members; sharing knowledge and skills; relationship with schools and community groups; decision-making through democratic process; cooperation among members; developing long-time friendships among neighbors.”* – Lamplight Community Garden

Perceptions of success might be influenced by the size of the garden (the SES variable RS3-1). Many scholars discuss garden's size as a factor associated with the successful gardening projects (Ostrom, 1999; Barthel et al., 2010; Krasny, 2009). The gardens' areas were determined in square meters and converted to acres (Appendix D). These areas fall in the 200-3000 m^2 range, with a few outliers (4,140 m^2; 4,743 m^2; 5,859 m^2; 6,138 m^2; 16,911 m^2). All these larger gardens indicated their perceptions of success as "very successful" (Figure 25). Larger gardens are able to accommodate more garden plots and also dedicate space for socializing, which contributes to higher perceptions of success. For example, one of the five largest community gardens in Austin - Adelphi Acre Community Garden - includes a playground for kids and areas dedicated for cooking lessons (Appendix C). It helps the garden to reach its goals of providing social gathering space and educating about safe, sustainable, and local food production.

A garden's size and longevity, level of participation, number of gardeners, socioeconomic attributes of members, and amount of social capital affect gardeners' perceptions of their success. Governance is another important factor that influences the success of community gardens. Studies have concluded that "successful" community gardens involve collaboration between different organizations, strong social capital, and high levels of community engagement (Diaz et al., 2018; Fox-Kämper et al., 2018; Howe and Wheeler, 1999; Stocker and Barnett, 1998). Scholars connect positive social capital with 'bottom-up' types of governance with a community's authority to create their own rules and norms (Rydin and Pennington, 2000). Next research question investigated the models of governance associated with different perceptions of success in community gardens in Austin.

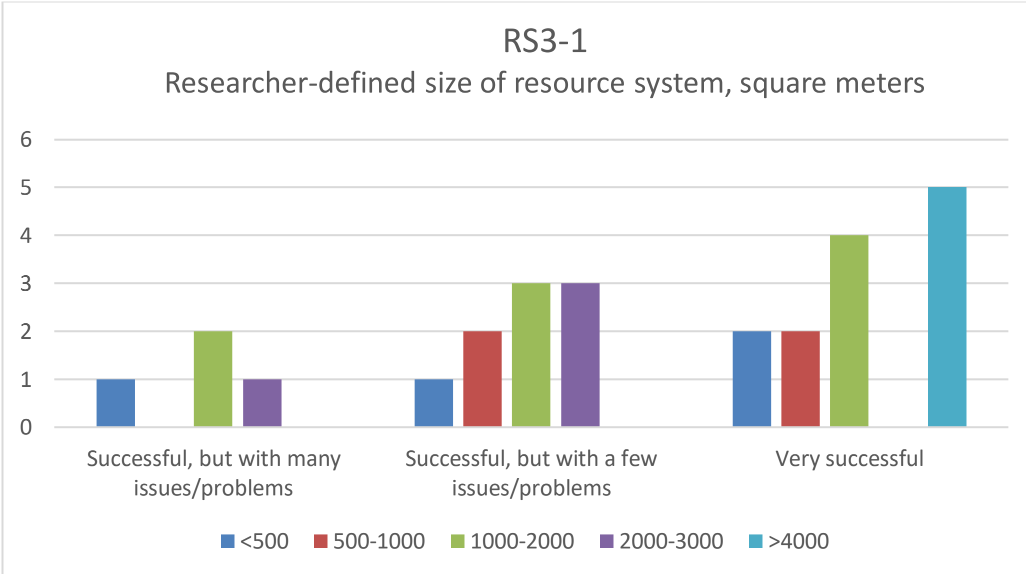


Figure 25: Community gardens' sizes by perceptions of success.

Research Question 2A: What is the relationship between models of governance and community gardeners' perceptions of success?

Two categories of gardeners' perceptions – "successful, but with many issues/problems" and "successful, but with a few issues/problems" – have a fairly equal distribution of 'top-down' and 'bottom-up' governance structures. No governance approach predominates in these two groups. Gardens that have many issues/problems do not employ the *'bottom-up': projects managed and run by local communities* model. This model of governance is associated with less extensive network structures, which can simplify the organization and management. Twelve community gardens in Austin perceive themselves to be 'very successful.' Three out of the twelve gardens use the *'top-down': projects managed by professionals but run by paid workers/volunteers* model. Two gardens use the *'bottom-up': projects managed and run by local communities model* (Figure 26).

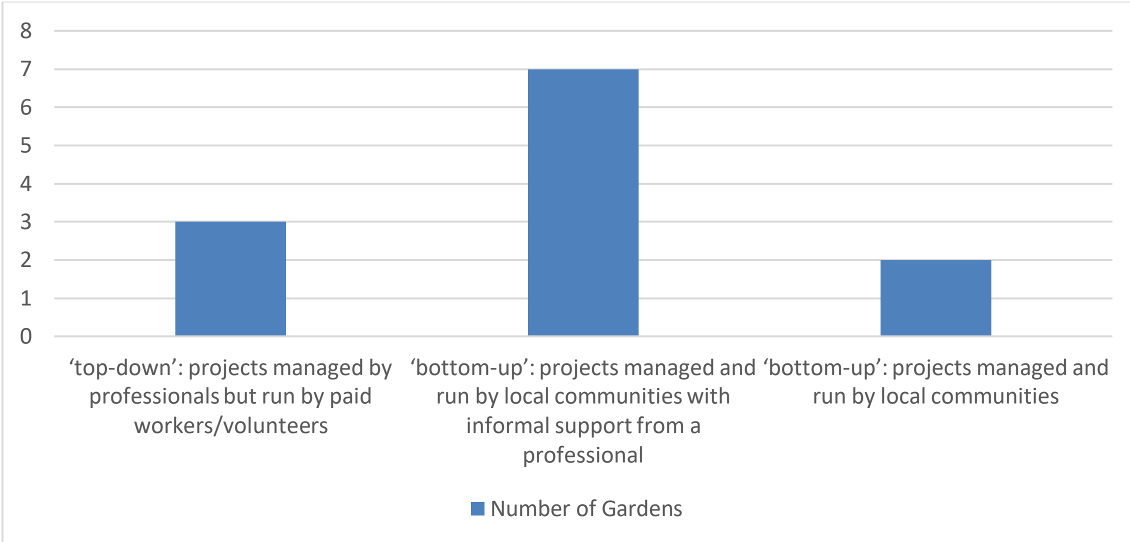


Figure 26: Models of governance used by 'very successful' community gardens.

The predominant model of governance is 'bottom-up': projects managed and run by local communities with informal support from a professional (seven gardens use this model) (Figure 26). This approach aids governance by providing external expertise through extended networks. Community members are still involved in the management of their gardens, but they also receive assistance from professional organizations. Thus, gardeners create ties with non-profit organizations, government agencies, and businesses to obtain materials, resolve land-use conflicts, or acquire other resources like information and advocacy support (Schmelzkopf, 2002; Baker, 2004). Scholars argues that community gardens depend on social networks to survive, function, and overcome barriers (Ghose et al., 2014). Decisions are more fully informed when there are external stakeholders involved (Colding et al., 2003). At the same time, this model of governance allows community members to manage and run the garden, which gives a feeling of control over the urban space and the feeling of power among marginalized or disadvantaged groups (Eizenberg, 2012). This can influence gardeners' perceptions of their success and their satisfaction with gardening. Collaboration with the government and NGOs can also positively affect outcomes, like ecological conditions and collective action. Professional expertise and governmental support provide stability and longevity to the garden (Palamar, 2010; Austin et al., 2006), which leads to higher perceptions of success. The most successful (the highest perceived success) gardens in the Austin area (founded in 1978, 1979, and 1981) are the oldest gardens (Figure 22). The 'very successful' category of community gardens in Austin contains the fewest gardens with decreasing involvement and the most gardens with stable participation (Figure 20). Participation in gardening reflects one of the principles of ethical action proposed by Gibson-Graham as principles of successful governance of commons (the principle of caring for – maintaining, replenishing, and growing – our natural and cultural commons). But are these principles applicable to the governance approaches used by community gardens in Austin?

Research Question 2B: What is the relationship between the success of community gardens and their commitment to the principles of 'ethical action'?

Key-informant interviews from the seven gardens that use the 'bottom-up': projects managed and run by local communities with informal support from a professional model were analyzed to determine whether these gardens follow the principles of ethical action (Figure 2) (Table 15):

The SES variable A6 (Norms (trust-reciprocity)/social capital) includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit,

Table 15: The SES variables used to assess the employment of principles of ‘ethical action.’

Open Code	Properties	Examples of participants’ words
RS7-1 Consistency of activity related to resource system	Describes a consistency of gardening activities: regularity of workdays, level of participation	Participation is stable/growing/decreasing Garden membership is constantly revolving and evolving Gardeners coming each day Monthly workdays/ assigned days to tend the garden
A2 Socioeconomic attributes	Includes socioeconomic and demographic characteristics of the gardeners	Age is for 60+ Seniors, Mostly Asians Families or couples in their late 20s/30s Post-grad students at the University of Texas
A6 Norms (trust-reciprocity)/social capital	Includes the aspects of community gardening that facilitate actions of cooperation for mutual benefit	Social exchange Social events Community workdays to encourage group cohesion outreach to the neighborhood sharing of knowledge
I1 Harvesting	This variable includes gardening activities related to crops/vegetables/fruits production as well as planting of flowers	Sustaining biodiversity Wide variety of regionally suited vegetables and herbs Plant fruit/nut trees
I7 Self-organizing activities	This variable includes activities related to self-governance, garden’s maintenance, formal and informal environmental education and leisure	park clean-up and maintenance events ‘hands-on’ learning about sustainable foods

	activities	Regularly held social events Labor Day party environmental classes weekly meetings
I8 Networking activities	This variable includes activities related to funding, external stakeholders, tenure secure, promotion, distributing surplus, etc.	collaboration with a local assisted living home building partnerships with local businesses learning lab for Cunningham Elementary students donate food to a nearby food bank donate to the women's shelter

which underlie the principle of *surviving together well and equitably*. Socioeconomic attributes (A2) of gardeners, (race and ethnicity, age, gender) and self-organizing activities (I7), such as social gatherings, cultural festivals, gardening, and cooking classes, also reflect this principle because they represent commitment to diversity, social inclusion, and equity.

All seven gardens in this category advocate for community building and positive social capital. They include members of all ages but are predominantly White. Only one community garden indicated commitment to racial and ethnic diversity: Festival Beach Community Garden, which collaborates with Multicultural Refugee Coalition (MRC) and involves people of several ethnicities – White, Asian, Black, Hispanic. To ensure participation of people with diverse backgrounds, this garden arranges interpreters for non-English speakers when needed.

> *"The garden has become a site of cooperation, collaboration, celebration, and developing friendships between diverse neighbors."* - Festival Beach Community Garden

> *"Adelphi Acre Community Garden is the result of a grassroots effort to create a thriving social space where neighbors can come together, grow together, and learn together."*

The principle of *distributing surplus to enrich social and environmental health* is achieved through ecological services and donations to food banks and other charities (SES variable I8). Five of seven community gardens act ethically by growing food on community plots and sharing it with the communities in need:

> *"One of our garden plots is a community plot, and all the produce from that plot goes to an assisted living home nearby."* – Cherry Creek Community Garden

> *"[We] give back to the community by participating in programs that set aside a portion of the harvest for community food banks in need of local, unprocessed foods."* - Anonymous Informant

> *"More than ten types of fruit trees provide fruit to be shared with low-income/food- insecure populations."* - Lamplight Community Garden

Only one of seven community gardens mentioned ecological services: "*We strive to serve north Austin by creating a sustainable urban-nature ecosystem that provides a habitat for wildlife (e.g., birds and bees).*" (Lamplight Community Garden). The analysis of key-informant interviews reveals that most community gardens in Austin do not include environmental outcomes in their goals. One of the possible explanations might be the low amount of awareness of the ecological services that are provided by community gardening.

Participation in charities shows commitment to the principle of *encountering others in ways that support their well-being as well as ours*. This principle also involves promotion of healthy lifestyles; this was mentioned by two of the seven gardens.

Consistency of activity related to resources (RS7-1) reflects the principle of *caring for – maintaining, replenishing, and growing – our natural and cultural commons*. Regularity of workdays and level of participation determines the amount of time invested in taking care of garden's space. All 'very successful' community gardens have required regular workdays. Only two of the seven gardens are struggling with decreasing participation. Gardeners take care of the natural commons by incorporating sustainable methods of organic gardening, such as by composting, collecting rainwater, conserving water, minimizing pollution, and avoiding fertilizers. The interviews indicated that all community gardens in this group follow the principle of *consuming sustainably*:

> *"The only rules to which everyone adheres are organic gardening procedures, no pesticides and water conservation."* – Faith Church Community Garden

> *"The Adelphi Acre Community Garden is dedicated to bringing sustainable agriculture to the North Austin area. We promote, educate, and disseminate information about safe, sustainable, and local food production and organic gardening techniques."*

The principle of *investing our wealth in future generations so that they can live well* is achieved by community gardens through environmental education of younger populations (the SES variable I7). One of seven community gardens offers free gardening classes throughout the growing seasons. Most community gardens conduct environmental education through informal learning:

> *"We provide opportunities for youth groups to take part in 'hands-on' learning about sustainable food, healthy lifestyles, and nutrition."* - PEAS Community Farm

The predominant model of governance used by community gardens with the highest perceptions of their own success – *'bottom-up': projects managed and run by local communities with informal support from a professional* – incorporates all six principles of ethical action proposed by the Diverse Economies framework as principles of successful governance, which supports the ideas of Gibson-Graham's work on the governance of the commons. Some of these principles were applied partially. Thus, the analysis of interviews did not reveal any evidence of *caring for – maintaining, replenishing, and growing – cultural commons* among the seven gardens with the analyzed governance approach. There was insufficient evidence of *distributing surplus to enrich environmental health* (only one out of seven gardens mentioned ecological services). However, most of the principles of ethical action received sufficient evidence from the key informants' interviews of 'very successful' gardens.

Some of the principles of ethical action, for example, the principle of *distributing surplus to enrich social and environmental health*, were missing in the governance of the community gardens with lower perceptions of the success. Analysis shows that most of the gardens with the lowest perceptions of the success do not produce food for donations. The exception is the Good Soil Community Garden, which is managed by a Christian nonprofit organization that promotes Christian values by feeding the homeless and lower income families in East Austin. Another principle of ethical action that is less associated with lower perceptions of the success is the principle of *investing our wealth in future generations so that they can live well*.

Two aspects of governance contribute to its success. First, community members are in charge of the decision-making and management, which is positively associated with the level of participation and gardeners' levels of satisfaction. Second, informal support from external organizations helps to promote adherence to principles of ethical action, which also contribute to successful governance. Collaboration with professional, non-profit, and governmental organizations is a result of community gardens following principles of "ethical action" like *distributing surplus* and *investing in future generation by providing environmental education*. On the other hand, gardeners were able to achieve these goals by extending the network system beyond their gardens through informal support from professional organizations. The principles of ethical action incorporate social, cultural, biophysical, and intellectual nature of community gardens as commons. Thus, the principle of *distributing surplus to enrich social and environmental health* requires the production of biomass to achieve social values, such as growing food to help those in need. The principles of ethical action reflect dual relationships between social and biophysical commons associated with community gardening. The next section examines the relationships between the models of governance and biomass production measured by the seasonal differences in carbon sequestration.

Ecological Performance: The Seasonal Differences in Carbon Sequestration

Research Question 3: How does carbon sequestration compare between growing and non-growing seasons?

Two values of NPP were calculated for each of the community gardens: one for a growing season (t1) and one for a non-growing season (t2) (Appendix H). July was chosen to represent the non-growing season; May represents the growing season. PlanetScope scenes from July 27th, 2018 and May 26th, 2019 were used to calculate NDVI (Figure 27). However, there were no images available on these dates for some of the gardens, therefore the data for the closest available dates were acquired (Appendix E).

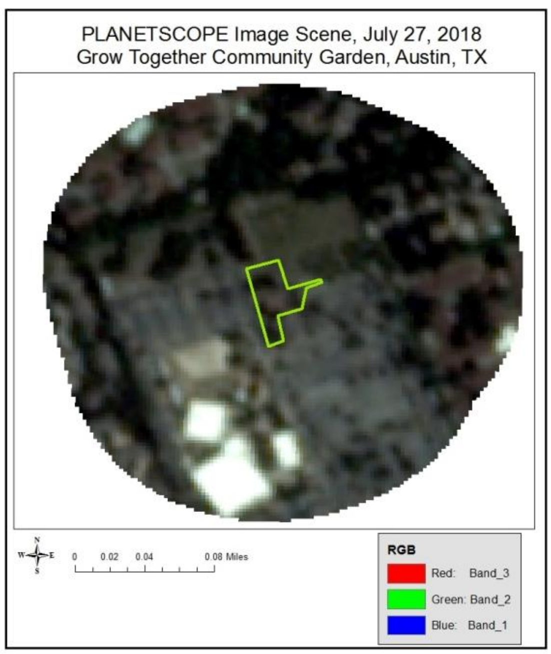


Figure 27: True color PlanetScope image of a community garden and its surrounding area

This analysis uses two ECOSTRESS image scenes: for August 2nd, 2018 and May 24th, 2019 because images for July were not available (Figure 28). The factors that have the same values for all of the gardens include T1, T2, ε°, and PAR. These values were determined for two different periods: the non-growing season (t1) and the growing season (t2) (Table 16). The average temperature in July is 30°C and the average temperature in May is 24°C (Table 3). Austin, TX has more than one growing season ("U.S. Climate Data", 2019); therefore, the maximum NDVI for the community gardens occurs in more than one month. May represents one of the months with maximum NDVI; therefore, T_{opt} is equal 24°C (the average temperature in Austin, TX in May). Green vegetation is expected where NDVI is between 0.2 and 0.8 and bare soil is expected when NDVI is slightly above zero (Horning, 2010). For most gardens the minimum NDVI values were more than 0.2 during non-growing seasons. Daily PAR values were converted from W/m^2 to MJ/m^2 using a conversion formula: 1 W = 1 J/s (Table 16).

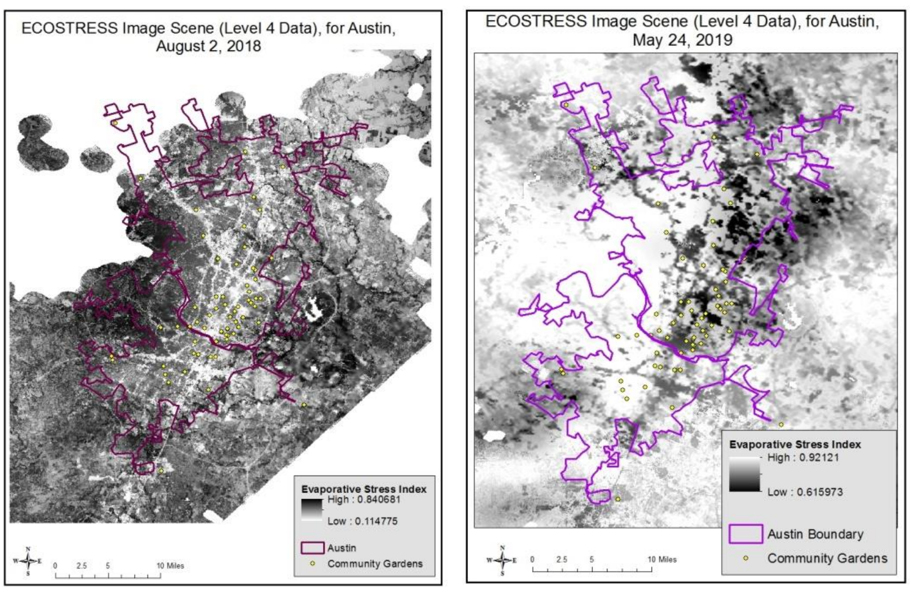


Figure 28: ECOSTRESS Level 4 data

Table 16: Daily values for non-growing and growing seasons

Temporal Period	ε°	T1	T2	PAR (W/m2)	PAR (MJ/m2)
July 27, 2018 (t1)	2.5	0.950	0.5	5.03	0.43
May 26, 2019 (t2)	2.5	0.998	1	4.71	0.41

For a non-growing season: T1 = 0.95 (Equation 8). The temperature scalar T2 is close to 0.5 because T_{mon} is above T_{opt} (Field et al., 1995). For a growing season: T1 = 0.998 (Equation 8). The temperature scalar T2 = 1 because $T_{mon} = T_{opt}$ (Field et al., 1995). The value of PAR was lower during growing seasons.

The ESI and NDVI values were calculated in ArcGIS for each community garden (Appendix F). The NDVI scenes were created individually for each garden. For some gardens, there was an increase in NDVI values during the growing seasons (Figure 29). For other gardens, NDVI values did not change, which might indicate a low gardeners' participation. The average mean NDVI value for a non-growing season was 0.42, for a growing season – 0.47.

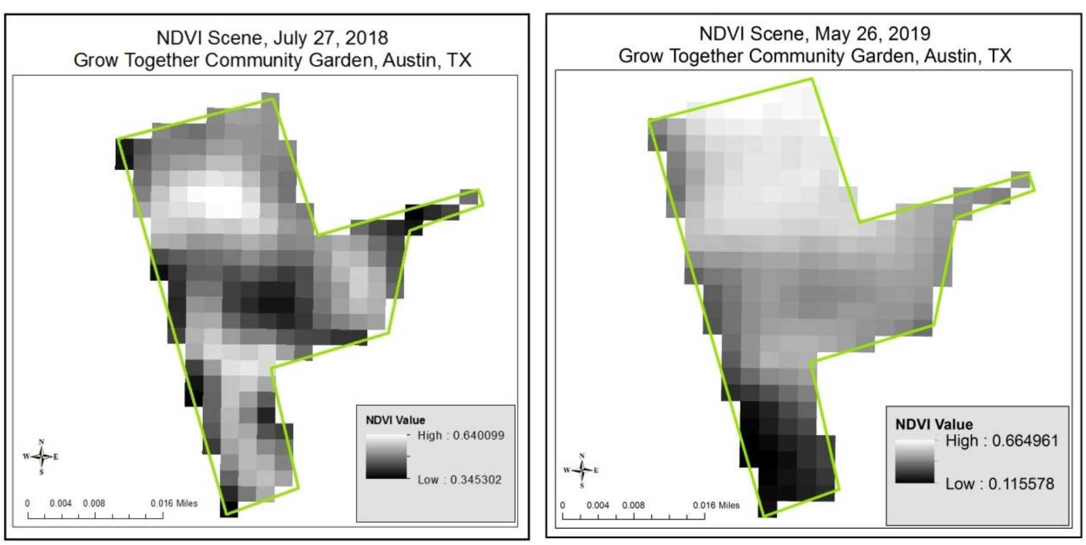


Figure 29: An example of the seasonal changes in NDVI in a community garden

The values of LUE and NPP for individual gardens are presented in Appendix H. The analysis revealed a seasonal increase in NPP values for all twenty-six community gardens participated in this study. A cumulative seasonal change in NPP was 223 percent (Table 17).

Table 17: Total NPP for non-growing and growing seasons.

Variable	t1	t2	% change
NPP (g)	12,415.8	40,108.47	+223.04

The results show that on July 27, 2018 (representing a non-growing season), a cumulative NPP of the community gardens in Austin was approximately 12.4 kg. During a representative period of a growing season (on May 26, 2019) the total amount of sequestered carbon was more than three times higher (40.1 kg).

Two-sample t-tests were applied in R Studio to statistically compare NPP values. The first t-test determines whether there is a significant difference in carbon sequestration between two seasons. The null hypothesis of the first t-test states that there is no significant difference between the seasonal mean values of NPP. The p-value of the test is 0.001235, which is less than the significance level alpha = 0.05 (Table 18). It allows for the rejection of the null hypothesis and acceptance of an alternative hypothesis that there is a significant difference between the seasonal mean values of NPP.

Table 18: The results of two-sample t-tests.

	t-test statistic value	df	p-value
t-test #1	-2.7342	50	0.008626
t-test #2	-2.7342	50	0.004313

The second t-test was applied to analyze whether the mean value of NPP during a non-growing season is less than the mean amount of NPP for the growing season. The alternative hypothesis of the second t-test states that mean NPP of a non-growing field is less than the mean NPP of a growing season. The p-value of the test is 0.0006173, which is less than the significance level alpha = 0.05 (Table 18). This result supports the alternative hypothesis: carbon sequestration by community gardens is higher during a growing season.

The lowest seasonal increase in NPP was recorded in the Good Soil Community Garden (88.06 g.). The highest seasonal increase in NPP was in the Sunshine Community Gardens (5502.08 g). The average increase in NPP was 1065.1 grams (~1 kg). Eight out of twenty-six gardens had a seasonal increase in carbon sequestration between two representative periods of more than 1000 grams (>1 kg) (Table 19).

Table 19: Community gardens with the highest seasonal changes in NPP (>1 Kg)

Community Gardens in Austin, TX	t1	t2	Seasonal difference (g)
	NPP (g)	NPP (g)	
Adelphi Acre Community Garden	891.9619	2150.687	1258.725
Deep Eddy Community Garden	849.7434	3647.591	2797.847
Festival Beach Community Garden	1328.6448	4881.851	3553.207
Lamplight Community Garden	639.9367	2847.141	2207.205
Patterson Park Community Garden	481.3478	2082.695	1601.347
South Austin Community Garden	536.0898	1560.814	1024.724
St. David's Foundation Community Garden	689.6593	1919.803	1230.144
Sunshine Community Gardens	3379.3285	8881.411	5502.083

Increase in NPP values depends on the three factors: PAR, LUE and NDVI (Equation 5). The values of PAR and LUE are based on the local climate conditions, while the values of NDVI depend on both climate and human efforts. Increase in NDVI values might indicate increase in human participation, extended and more frequent working hours, and improvement in gardening skills. These aspects of community gardening are affected by how a garden is organized and managed. Next research question attempts to analyze the relationships between the seasonal changes in carbon uptake and governance approaches.

Research Question 3A: What is the relationship between models of governance and seasonal differences in carbon sequestration?

Most of community gardens with low seasonal changes in NPP (less than 300 grams) have small areas. The lowest change in NPP between a growing and non-growing seasons was registered in the Good Soil Community Garden, which is also experiencing a decreasing participation. This garden applies a governance approach: *'top-down': projects managed by professionals but run by paid workers/volunteers* and has the smallest small area among the analyzed gardens. It also has low perceptions of its success (successful, but with many issues/problems). Thus, availability of space affects the amount of biomass produced. However, some of the larger gardens also had a low seasonal change in NPP and a decrease in the NDVI values (for example, Alamo Community Garden, Garden of Eatin' at South Austin Senior Activity Center, Asian American Resource Center Program Garden). Another example of the garden with one of the lowest seasonal changes in NPP is Rollingwood Community Garden. However, this garden is among the most populous gardens and has an increasing participation. Low biophysical productivity in Rollingwood Community Garden might relate to the primary purpose of this garden, which includes community building and social exchange.

Therefore, the management in this garden focuses on the socializing rather than production of biomass.

Sunshine Community Garden demonstrated the highest increase in NPP (5502.083 grams). This garden is a non-profit organization with a 'top-down' governance structure. However, NDVI values during the growing season in this garden were lower than values recorded for the non-growing season. Six out of eight community gardens that showed a high increase in NPP (>1 kg), also demonstrated an increase in NDVI values. This means that the changes in carbon sequestration associated with these gardens might be influenced by human factors, such as participation. None of the gardens that have a seasonal increase in NDVI values use a 'top-down' type of governance (Table 20).

Two out of six community gardens with the highest changes in NPP utilize the governance approach *'bottom-up': projects managed and run by local communities*. Most of the gardens in this category utilize the model of governance *'bottom-up': projects managed and run by local communities with informal support from a professional*. Next research question investigates whether the principles of 'ethical action' are applicable to the governance approaches utilized by community garden in Austin with high seasonal changes in carbon sequestration.

Research Question 3B: What is the relationship between levels of carbon sequestration and community gardens' commitment to the principles of 'ethical action'?

Similar to the analysis for the research question 2B, key-informant interviews from the six gardens that demonstrated high increases in carbon sequestration and utilized models of governance *'bottom-up': projects managed and run by local communities with* *informal support from a professional* and *'bottom-up': projects managed and run by local communities* were analyzed to determine if these gardens follow the principles of ethical action (Figure 2). The first principle - *surviving together well and equitably* – was investigated through the analysis of the SES variables A6 (Norms (trust-reciprocity)/social capital), A2 (Socioeconomic attributes) and I7 (Self-organizing activities) (Table 2). These variables demonstrate gardens' commitment to diversity, social inclusion, and equity or its absence. Four out of six community gardens indicated commitment to the ethnic diversity. These gardens have members that represent different minority ethnic groups – Asian, Black, Hispanic. All six community gardens in the analyzed category advocate for community building and positive social capital. For example, Lamplight Community Garden describes its values as:

> *"Accessibility, affordability, elderly and intergenerational participation, appreciation of human and cultural differences, building relationship with schools and community groups, and developing long-time friendships among neighbors."*

Table 20: Models of governance associated with high differences in carbon sequestration (>1kg) and increase in NDVI values

Community Gardens in Austin, TX	Seasonal difference in NPP (g)	Model of Governance
Deep Eddy Community Garden	2797.847	‘bottom-up’: projects managed and run by local communities
Festival Beach Community Garden	3553.207	‘bottom-up’: projects managed and run by local communities with informal support from a professional
Lamplight Community Garden	2207.205	‘bottom-up’: projects managed and run by local communities with informal support from a professional
Patterson Park Community Garden	1601.347	‘bottom-up’: projects managed and run by local communities
South Austin Community Garden	1024.724	‘bottom-up’: projects managed and run by local communities with informal support from a professional
St. David’s Foundation Community Garden	1230.144	‘bottom-up’: projects managed and run by local communities with informal support from a professional

The principle of *distributing surplus to enrich social and environmental health* is achieved through ecological services and donations to food banks and other charities (the SES variable I8). This analysis shows that most of gardens with low seasonal changes in NPP do not produce food for donations (except for the Good Soil Community Garden). Four out of six community gardens with the highest seasonal change in NPP follow this principle of “ethical action” by growing food on the community plots and donating to local food banks. Three out of six community gardens indicated biodiversity as one of their values:

“We have perimeter community garden beds which are planted with plants which are larval and nectar food sources for a variety of butterflies, bees, and other insects.” – Patterson Community Garden

"The Habitat Areas Team works to develop, enhance, and maintain designated habitat areas in the garden to provide a natural environment for beneficial wildlife (including birds, butterflies, frogs, toads, and other creatures). They also help provide education on habitat preservation, development, and maintenance. Sustaining biodiversity is one of the garden's most important missions." – Festival Beach Community Garden

Although key-informants were unaware of carbon sequestration as an environmental benefit of gardening, this analysis shows that all twenty-six gardens had higher NPP during a growing season. The principle of *encountering others in ways that support their well-being as well as ours* is followed by all community gardens through the promotion of organic food consumption:

> *"[We] provide our gardeners and their families with a reliable source of fresh, nutritious and affordable food."* – Festival Beach Community Garden

The principle of *caring for—maintaining, replenishing, and growing—our natural and cultural commons* is achieved through sustainable methods of organic gardening, consistent participation, regular workdays, and involvement in taking care of the garden's space. All gardens with a high increase in NPP indicated stable or growing participation in gardening and have people signed for waiting lists. However, three out of six gardens struggle with members' involvement in garden's maintenance:

> *"Gardeners are not taking care of their volunteer responsibilities (2 hours / month is required)."* - Anonymous Informant

> *"Participation in our mandated community work hours has always been*

problematic, with a relatively few number of members contributing to the overall maintenance of the garden." – Patterson Community Garden

According to key-informant interviews, all community gardens with high seasonal change in NPP follow this principle of *consuming sustainably* by applying sustainable methods of organic gardening, such as composting, collecting rainwater, conserving water, minimizing pollution, and avoiding fertilizes. The principle of *investing our wealth in future generations so that they can live well* is achieved by community gardens through educating younger population (the SES variable I7). Two out of six community gardens mentioned environmental education in their interviews:

"A special stewardship team is dedicated to educating our gardeners and members of the community interested in gardening" – South Austin Community Garden

"[We] provide education on habitat preservation, development, and maintenance." - Festival Beach Community Garden

To summarize, the two models of governance used by community gardens with the highest increases in NPP – *'bottom-up': projects managed and run by local communities with informal support from a professional* and *'bottom-up': projects managed and run by local communities with informal support from a professional* – incorporate five out of six principles of ethical action proposed by the Diverse Economies framework as principles of successful governance. The principle of *investing our wealth in future generations so that they can live well* has been demonstrated by only two out of six community gardens in the analyzed category. The analysis of interviews also did not reveal sufficient evidence of *caring for – maintaining, replenishing, and growing – cultural commons* among these six gardens. However, most of the principles of ethical action received sufficient evidence from the key informants' interviews. Some of the principles of ethical action (for example, *distributing surplus to enrich social and environmental health*) seems to be less present in the governance of the gardens with low seasonal changes in NPP.

CHAPTER VI

DISCUSSION AND LIMITATIONS

Limitations

There are several limitations to this study that must be made clear. One is the number of key informants that participated in the interview process. Out of fifty-one known community gardens, only twenty-six had representatives who agreed to be interviewed. Most of the interviews were conducted during the COVID-19 pandemic which likely affected the data collection. Social distancing – a crucial measure for slowing the spread of COVID-19 – might have negatively affected the participation in community gardening and slowed the interview process. Many representatives of community gardens in Austin who initially agreed to participate in the interview became unavailable during the COVID-19 pandemic. This research analyzed participants' perceptions of the success of community gardens. Some of key-informants might have not expressed their true opinions regarding the gardens' success due to their specific roles of managers or PRs.

There are also limitations to the calculations of NPP. First, the boundaries of the community gardens were manually delineated in ArcGIS software using the best estimation approach. Although previous research suggests that high resolution remote sensing imagery allows for accurate delineation of a site's boundaries (Forkuor et al., 2014), there is still a certain degree of error, for example, due to clouds or shadows. Second, the NPP values were calculated for the entirety of each garden. But other land covers like concrete sidewalks, footpaths, worktables, seating areas, etc., that are not garden plots, trees, or shrubs are also within the delineated patch (Figure 30, Figure 31). These areas were not excluded from the analysis, which likely affected the accuracy of the calculations. Developing a database with the percentages of the areas in Austin's community gardens that are used for production would provide significant benefits for this study and future research. Future research can also compare NPP of gardens with NPP of empty lots to analyze the differences in carbon sequestration by urban agriculture and natural vegetation possibly occupying empty lots (such as, grass). Third, there is a slight date mismatch for some satellite images. For example, for a non-growing season the ECOSTRESS scene represents August 2nd, while most of the PlanetScope images are from July 27th. This is because ECOSTRESS scenes for July were unavailable for Austin. This matter may have caused some inaccuracy in calculating daily carbon uptake.

Figure 30: Dottie Jordan Recreation Center Senior Garden

Figure 31: Adelphi Acre Community Garden

Source: Coalition of Austin Community Gardens (https://communitygardensaustin.org/gardens/)

This study statistically compares the seasonal carbon uptakes to stress the importance of the gardening in urban environment. Amounts of carbon dioxide absorbed daily were calculated for growing and non-growing seasons to show the difference in the carbon uptake when there was little or no human activity. The results of two-sample t-tests show that the carbon uptake was higher during the growing season. These values would not be constant throughout the seasons of course; in fact, they would vary every day for crops and flowers because their biomasses change as they grow. Previous research shows that carbon sequestration values are more stable for trees (Jo, 2002). Therefore, gardens with fruit trees would absorb more carbon than the gardens with just vegetables and flowers (Jo, 2002). However, carbon is also being released during the tree maintenance process (Nowak et al., 2002). Some studies also emphasize the importance of vegetation structure, specifically the leaf angle distribution (LAD), in calculating APAR (Huemmrich, 2013). Future analysis needs to account for LAD and its role in the relationships between APAR and NDVI.

Although this analysis only considered the contribution of the gardens' vegetation to carbon sequestration, soil also accumulates and stores organic carbon from plants and animals. The role of soil in carbon uptake in urban areas was previously discussed by the scientific community. Around 80 percent of terrestrial organic carbon is in the soil (Ontl and Schulte, 2012). The concentration of carbon in soil is highest in the first 20 centimeters of topsoil (Toth at al., 2013). Edmondson et al. (2012) argues that the amount of organic carbon deposited in urban soil is higher than in agricultural soil. Kuittinen et al. (2016) states that soils in urban areas store 82 percent of all organic carbon, and the accumulation is greater under trees and woody vegetation. On the other hand, soils also release carbon back to the atmosphere during some gardening practices, such as planting (Cameron et al., 2012; Nowak and Crane, 2002), and through oxidation (Bolinder et al., 2007). Additional research is needed to account for the amount of carbon dioxide stored and released by soil. The human factor is important because gardeners decide what techniques and methods to use. For example, putting a lawn or other cover crop on land that are not planted in crops can prevent the loss of carbon through oxidation (Zirkle et al., 2011). Composting is another example of a practice that has a low carbon cost comparing to the use of fertilizers (Cameron et al., 2012; Lillywhite and Rahn, 2008). The process of composting reduces greenhouse gases (National Geographic, 2016). Composting sites associated with community gardens also help to sequester carbon dioxide, but it is up to people to learn and implement methods of sustainability. Community gardening education can facilitate environmental outcomes through the passage of knowledge about environmentally responsible behaviors, sustainable planting, and tending techniques, composting, etc. (Krasny, 2009). As a result, intellectual commons associated with community gardens affect their biophysical commons. Further analysis is required to fully understand all the barriers and facilitators of carbon sequestration related to community gardening.

Socio-ecological Outcomes: The Phenomenon of "Socionature" in Community Gardening

This dissertation argues that social and ecological outcomes of community gardening are co-dependent and affect each other. The governance approach determines what forms this interdependence takes. Sustainable and organic food production was the most common primary goal of community gardens in Austin. The ability to achieve their goals influences gardeners' perceptions of their success, which represent social outcomes in this research. Food production through gardening involves interaction with and transformation of nature and results in the production of biomass. The process of gardening cannot be conducted without people. Social outcomes of gardening are affected by garden's productivity and ecological outcomes are affected by the amount of time and effort dedicated by the gardeners to the production of food. Three community gardens – Deep Eddy Community Garden, Festival Beach Community Garden, and Lamplight Community Garden – were the gardens with the highest perceptions of success and the highest seasonal changes in NPP. All three use a 'bottom up' governance approach (Table 21). None of the gardens that have a high seasonal change in NPP with an increase in the amount of biomass use 'top-down' governance structures. A possible explanation is that many community gardens in Austin with 'top-down' models of governance focus more on social inclusion and social exchange (for example, senior centers) that happen through the production of food rather than on the food produced.

Table 21: Community gardens with the highest seasonal changes in NPP, their models of governance and perceptions of success

Community Gardens in Austin, TX	Seasonal difference in NPP (g)	Model of Governance	Perception of Success
Deep Eddy Community Garden	2797.847	'bottom-up': projects managed and run by local communities	Very Successful
Festival Beach Community Garden	3553.207	'bottom-up': projects managed and run by local communities with informal support from a professional	Very Successful
Lamplight Community Garden	2207.205	'bottom-up': projects managed and run by local communities with informal support from a professional	Very Successful
Patterson Park Community Garden	1601.347	'bottom-up': projects managed and run by local communities	Successful, but with a few issues/problems
South Austin Community Garden	1024.724	'bottom-up': projects managed and run by local communities with informal support from a professional	Successful, but with a few issues/problems
St. David's Foundation Community Garden	1230.144	'bottom-up': projects managed and run by local communities with informal support from a professional	Successful, but with many issues/problems

The SES framework applied by this research reflects both social and natural aspects of community gardening that work in tandem to create ‘socionature’ in an urban area. UPE theory argues that nature and society are co-constituted in a way that political, social, economic, cultural, and ecological factors affect nature in the city but also are affected by it (Classens, 2015). Community gardens are a part of urban environment that is socially constructed and integrates political structure, community culture, identity, and socio-nature relationships. This argument supports the UPE ideas of co-production of society and nature (Alkon, 2013; Moragues-Faus, 2017).

Community gardens create positive social capital (such as networks, norms, and trust, that facilitate actions of cooperation for mutual benefit) through the production of natural capital. Gardeners meet, communicate, collaborate, make decisions, and exchange knowledge through the gardening process. Social capital represents social commons that can affect biophysical commons. For example, many community gardens in Austin promote inclusion of people with disabilities in gardening activities. They provide raised beds to improve access for people in wheelchairs (Figure 32). This creates a layout that leaves less space for food production compared to other gardens, and this results in less biomass (Figure 33).

Figure 32: Raised beds in the Sunshine Community Garden

Figure 33: Vegetation in the Lamplight Community Garden

Each garden's goals and values affect the distribution of the different functioning zones within that garden. Thus, many gardens in Austin that involve families with young kids dedicate space for a playground. Gardens that pursue community building and social exchange create gathering spaces for socializing (Figure 34). While serving a goal of "*bringing together diverse neighbors to encourage cooperation, collaboration and friendship*" (from the interview with the Labyrinth Community Garden), these areas reduce the gardening space, which would lower NDVI values. Gardeners also choose the mixture and physiological characteristics of plants, which also impacts NDVI values.

Figure 34: A gathering area in the Labyrinth Community Garden

Intellectual commons in community gardens include social-ecological memory, management and governance techniques, gardening experience and ecological knowledge. Intellectual commons produce social commons. Six interviewed community gardens in Austin provide formal environmental education by conducting environmental classes among the younger population and adults. One of them, PEAS School and Community Farm and Urban Orchard collaborates with the Cunningham Elementary school and teaches approximately 400 students of all grades per year. Rollingwood Community Education Garden offers guided tours to Austin residents to promote sustainable recourse use and organic gardening. It also offers gardening classes for kids. This exchange of knowledge creates social networks and social capital, which are a part of social commons:

> *"A primary purpose of these gatherings is to provide a sense of community among members in which we can get to know each other on a more personal level. The gathering time also serves as a time of planning and organizing garden affairs. It is often during this time recent observations and knowledge of gardening is shared. I usually have a short lesson planned and a list of tending or maintenance tasks to assign to garden members."* – Rollingwood Community Education Garden

On the other hand, it depends on the networking, level of trust, and sense of community affected by the social commons. Cultural commons, like cultural exchange, collectively created art objects, religious objects, and other products of reification, depend on the community input and the strength of collective action, which benefit from positive social capital. Collectively created physical objects that have special meanings for a garden's members (for example, a meditation labyrinth in the Labyrinth Community Garden and art objects in the St David's Foundation Community Garden) provide gardeners with a sense of pride and unity and might influence their perceptions of the garden's success.

Interrelationships Between Social and Ecological Performance

Ecological performance is represented in this research by the potential of carbon uptake in community gardens through photosynthesis. This analysis statistically compared the carbon uptakes during growing and non-growing seasons to stress the importance of the gardening in urban environment. The results of two-sample t-tests show that the carbon uptake was higher during the growing season. This study did not strive to determine the exact amount of carbon sequestered by community gardens in Austin, TX. Neither has it claimed the absolute benefits of gardening in terms of climate change mitigation. Rather, it attempts to understand what factors determine the ability of community gardens to sequester carbon dioxide and how humans are related to these factors, which are represented by the variables in the NPP formula. While some of the variables (such as PAR and LUE) are biophysical phenomena and depend on the specific characteristics of a geographical location (climate, latitude) and the position of the sun, others (like NDVI) partially depend on human activity. Indeed, the garden members decide what type of plants and how many of them to grow, as well as how often to participate in the gardening process. The quantity of a garden's biomass is related to the time and effort invested by the gardeners (Figure 35) that produce vegetation that would not exist without the work of a gardener (Figure 36).

NPP depends on the three factors: PAR, LUE and NDVI (equation 5). The value of PAR was lower in May (a growing season). Therefore, NPP has increased due to the changes in NDVI and LUE. Thus, higher values of ESI in May (meaning less water stress) contributed to the increase in LUE and, consequently, NPP (Appendix H). The amount of biomass produced by the garden depends on the climate of the area, a soil type, and other important factors, such as the utilized area, vegetation types, and the number and frequency of the growing season. The climate of Austin allows almost a

Figure 35: Plots at the Festival Beach Community Garden before a growing season

Figure 36: Plots at the Festival Beach Community Garden during a growing season

Source: Coalition of Austin Community Gardens (https://communitygardensaustin.org/gardens/)

year-round growing season except January and with the limitations in July and August due to the high heat and humidity ("U.S. Climate Data", 2019). Therefore, the productivity of the gardens depends on how they are operated and managed, what goals they pursue, how many and what types of plants gardeners decided to grow. Socio-ecological memory, traditions, rules-in-use and norms affect ecosystem services, because they are reflected in the gardens as physical objects, including the amount of biomass

(Barthel et al., 2010). Dennis and James (2016) emphasize the significance of stakeholder participation in environmental stewardship of urban green spaces and its contribution to the adaptive capacity of social–ecological systems. In community gardens, environmental stewardship is carried out by those in charge of the decision-making process. Based on the model of governance, it can be gardeners or garden's managers, external organization or local government (McGlone et al., 1999; Fox-Kämper et al., 2018). For example, gardeners' decision to grow fruit trees can increase a garden's NPP, because the trees absorb more carbon than crops (Cameron et al., 2012; Talk, Earth. "Which Trees Offset Global Warming Best?"). NDVI values were higher in May for some of the gardens and lower for others. The differences in participation levels can be a possible explanation for that. Previous research also states that an increase in community participation in urban gardens is positively correlated to food provision (Dennis and James, 2016). Three out of six community gardens in Austin that have the highest seasonal increase in NPP with a simultaneous increase in the mean NDVI values indicated increasing levels of participation, and the other three gardens have stable participation (Appendix G). Consequently, the biophysical productivity depends on the number of gardeners. There are five gardens in Austin with more than 50 members; four of them have a high seasonal increase in NPP (Appendix G). Therefore, a garden's biophysical productivity depends on social factors. Future research should analyze other environmental benefits of the community gardens as an outcome of the certain governance models, gardeners' motivations and level of participation.

The effects of the governance structure on the social and ecological performances require the discussion of other aspects of community gardening, such as garden's purposes and values, socioeconomic characteristics of the participants, existing issues and problems, source of funding, etc. The choice of governance depends on the spatial interaction of actors with networks, politics, economics, and environmental conditions in which a garden operates.

The choice of a governance approach can be influenced by the purpose of a community garden. Analysis of interviews determined several primary purposes of community gardening in Austin:

1. Sustainable, community-based agriculture and organic food production.

2. Provide fresh food for low-income residents.

3. Community building and social exchange.

4. Social inclusion.

5. Environmental education.

Many community gardens indicated more than one primary goal from the list above. The relationships between primary goals and models of governance help to reveal what factors affect the governance structure (Figure 37).

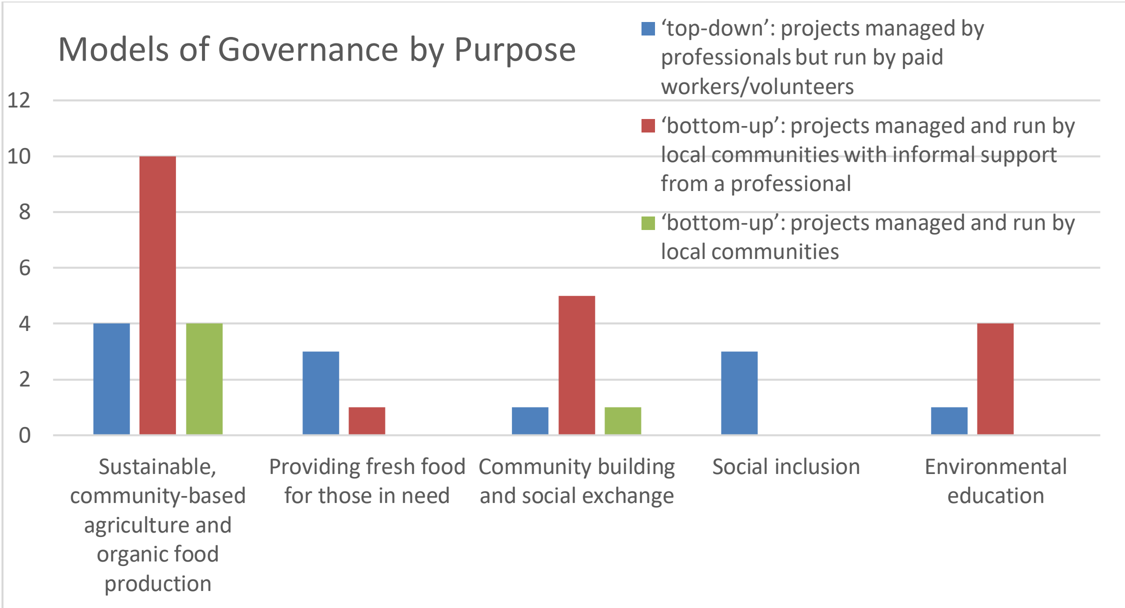


Figure 37: Models of governance of community gardens in Austin by purpose.

The most common primary goal of community gardens in Austin regardless their governance approach is sustainable and organic food production. However, all gardens whose primary purpose is to grow food, also indicated at least one secondary purpose. Only gardens with a governance structure *'top-down': projects managed by professionals but run by paid workers/volunteers* indicated social inclusion as their primary goals. These gardens are managed by senior centers and aim to improve the lives of older adults by involving them in the community.

According to this analysis, gardens that grow food primarily to help those in need (low-income citizens, homeless, women's shelter) receive support from the non-profit organizations and businesses. The same model of governance (*'bottom-up': projects managed and run by local communities with informal support from a professional*) is associated with environmental education. Gardens with the governance structure 'bottom-up': projects managed and run by local communities operate primarily for sustainable and organic food production. This purpose is also associated with the highest perceptions of the success (Figure 38).

Barthel et al. (2010) argue that rule monitoring, enforcement, and sanctioning are more effective within smaller community gardens. Krasny (2009) states that environmental education is more likely to occur in smaller, enclosed community gardens that favor communication between gardeners. This analysis did not reveal any significant relationships between the governance approaches and gardens' sizes (Figure 39). Most of the largest gardens (>4000 m^2) are managed by community members with informal support from external organizations.

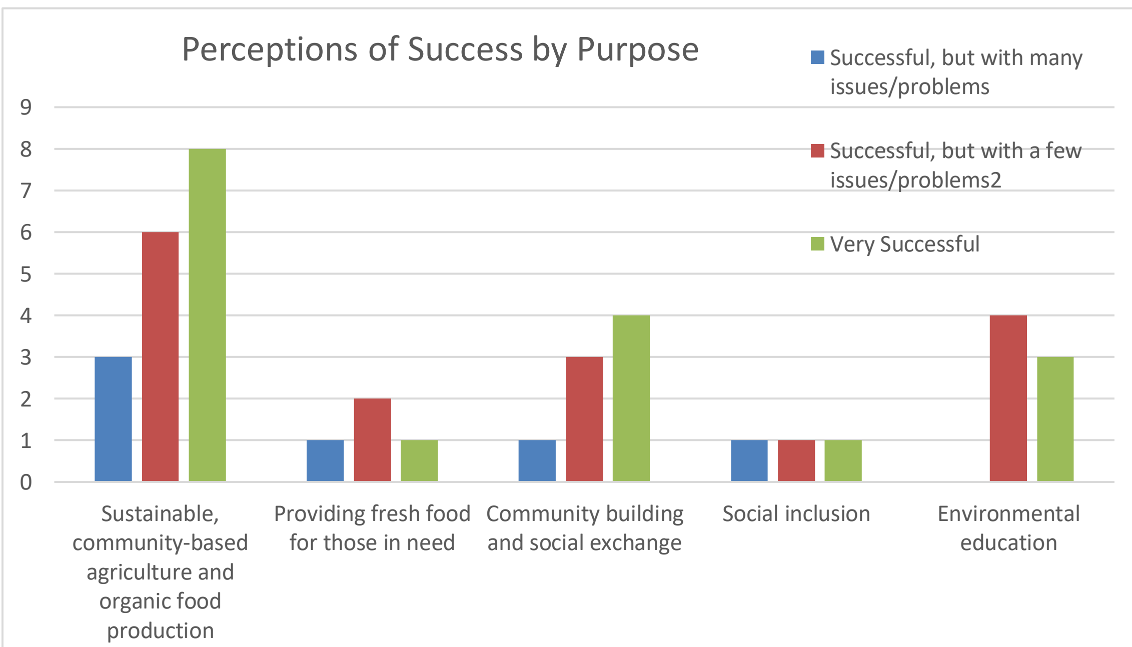


Figure 38: Perceptions of the success of community gardens in Austin by purpose.

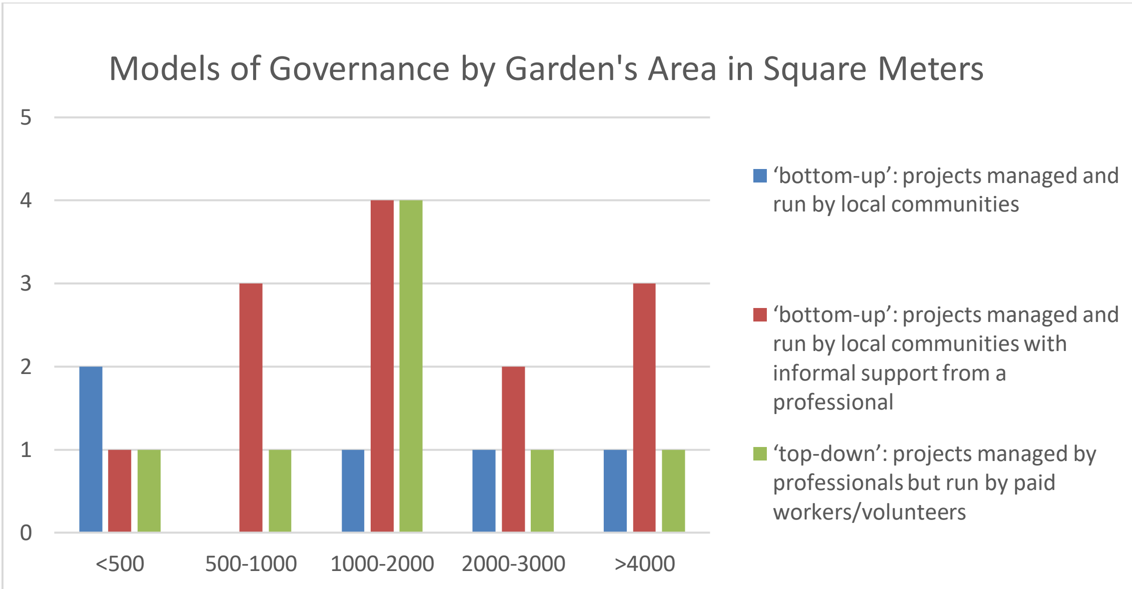


Figure 39: Models of governance of community gardens in Austin by garden's area.

The key informants were asked to identify any issues, problems, or concerns that they are experiencing in their community garden. Five main categories of issues/problems were established (Figure 40):

1. Funding. Some gardens experience a funding shortage and require additional funds to cover different expenses, such as obtaining tools, materials, seeds, etc. Example:

> *"We need new tools for the garden (we started with used, donated tools), but we have been unsuccessful in obtaining grant funding for these tools. We sit on the edge of two widely diverse socio-economic groups, so we have been turned down for City grants because of our location. Funding for items such as tools has been an ongoing struggle since we became*

established." – Cherry Creek Community Garden

2. Pests, bug infestation, weeds, water shortage.
3. Governance. This category includes problems with organization, leadership, communication, and networking. Examples:

   "Gardeners want to be involved and participate but don't want a leadership role." - St. David's Foundation Community Garden

   "Understanding the best management and policies to govern the garden [needed]" - St. David's Foundation Community Garden

   "Some people are disappointed that there isn't more community." – Hyde Park Community Garden

   "Lack of consistent communication which we are trying to improve." – Emerald Wood Community Garden
4. Participation. This category includes both low participation and high demand on plots (long waiting lists). Some gardens experience low involvement in common duties, such as maintenance of common areas.

   "…a relatively few number of members contributing to the overall maintenance of the garden." – Patterson Park Community Garden

   "Gardening is often a lower priority to a lot of other intense life activities (work, school, raising kids, extracurricular activities, etc.)." – Rollingwood Community Garden

   "Low participation makes it hard to keep up the garden common areas."–

Unity Park Community Garden

"It seems that people enjoy working on their plots and running into other gardeners occasionally but are less likely to participate in group activities." – Emerald Woods Community Garden

5. Experience in gardening. Example:

"…many gardeners are new to gardening and productivity is low." - Anonymous Informant

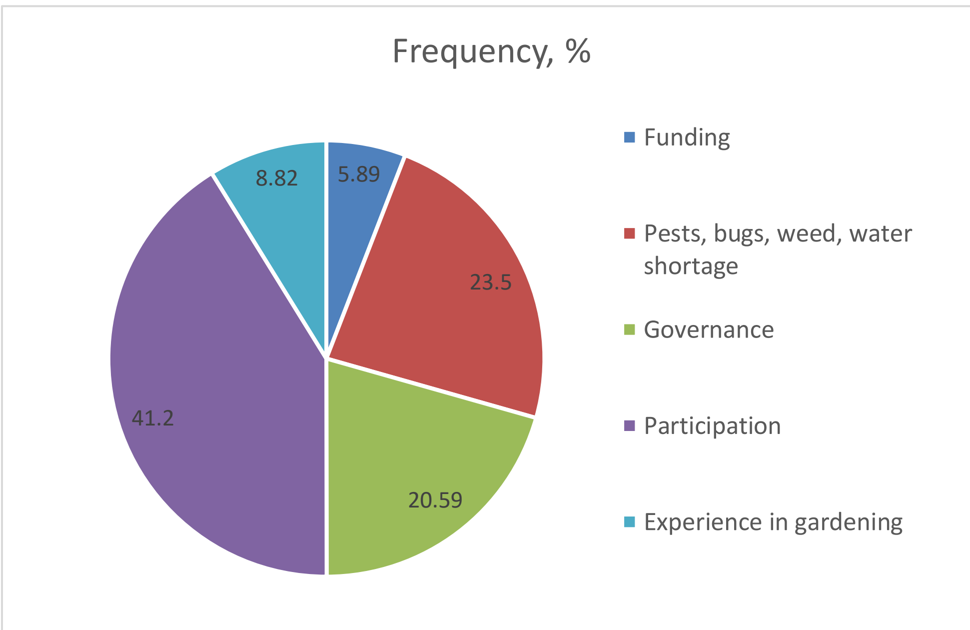


Figure 40: Categories of issues/problems identified by community gardens.

Participation was the most common problem among the interviewed gardens. It is almost equally experienced by all three governance approaches. In community gardens, participation is a fundamental aspect as it creates both physical objects (individual plots, functioning zones, and biomass) and social capital (networks, socio-ecological memory, social exchange). Participation levels reflect a garden's value to the community. Low participation leads to low amounts of biomass in the garden and weak social capital. On the other hand, weak social capital (low levels of trust and cooperation, unwelcoming atmosphere) can negatively affect participation. In fact, participation issues in some interviewed community gardens resulted from poor management and/or communication:

> *"It seems that people enjoy working on their plots and running into other gardeners occasionally but are less likely to participate in group activities. This is partly due to a lack of consistent communication which we are trying to improve."* - Emerald Wood CG

> *"Participation in our mandated community work hours has always been problematic, with a relatively few number of members contributing to the overall maintenance of the garden."* - Patterson Community Garden

These are examples of conflicts between individual and community interests that were described by Taylor (1990). Some gardens struggle with involving people in garden maintenance or working on the common plots – types of collective action that define community gardens as commons. But economic incentives provided by municipalities can facilitate community gardens. In Austin, economic incentives are provided by the Sustainable Food Center (SFC) by carrying gardens' insurance policies and paying their water bills. Gardens that collaborate with the SFC have stable participation by members. On the other hand, community gardens with the highest autonomy *('bottom-up': projects managed and run by local communities*) do not experience problems with members recruitment (Figure 41). These gardens operate independently from any external organizations. Scholars argue that external stakeholders can impose their own interests and goals on the gardeners (Ghose et al., 2014). Participation levels are higher when people share common interests and enjoy collective efforts (Colding and Barthel, 2013).

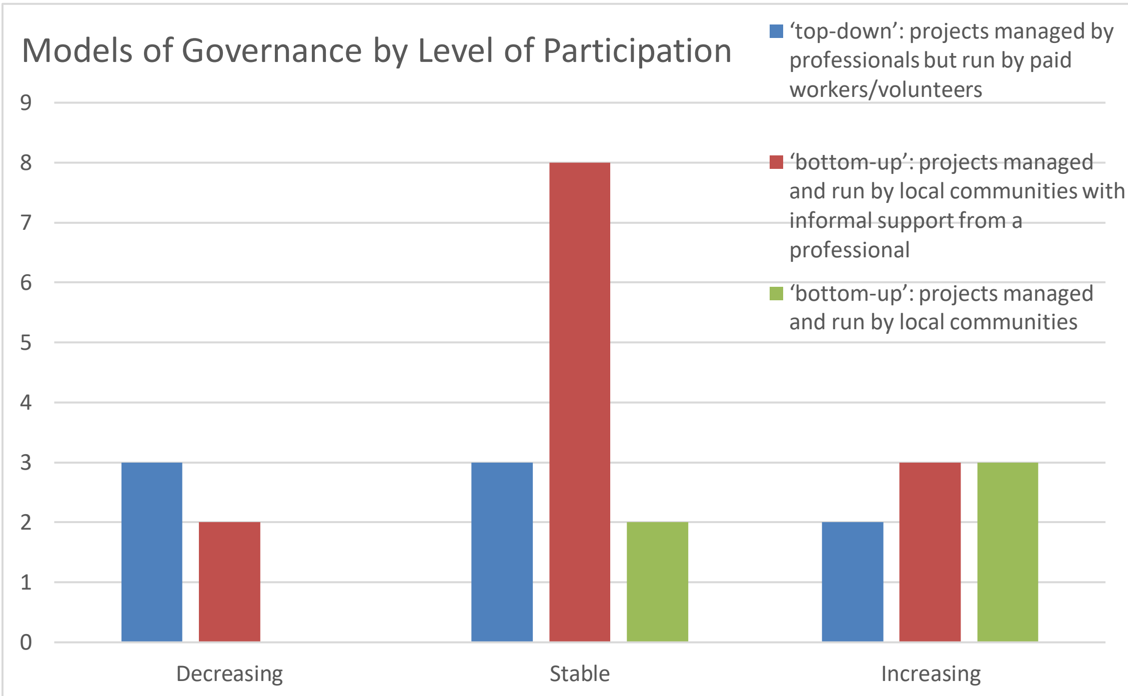


Figure 41: Model of governance by the level of participation in community gardens

Several key informants included weak governance in the list of problems. These issues are related to weak management/organization:

> *"A challenge that we have been trying to better address is organization and communication. We have been trying to engage the gardeners in group workdays and other fun events at the garden but find that it's difficult to organize and participation is low when something is organized."* – Emerald Wood Community Garden

"The biggest challenge is organization and leadership. Specifically:

- *Gardeners want to be involved and participate but don't want a leadership role*
- *Frequent turnover and gardeners going inactive in their plots and not taking care of their volunteer responsibilities (2 hours / month is required)*
- *Setting a bigger vision for what the garden could be*
- *Understanding the best management and policies to govern the garden"* - St. David's Foundation Community Garden

Most of the gardens that experience issues with governance rated their perceptions of success as 'successful, but with a few issues/problems' and use the *'bottom-up': projects managed and run by local communities with informal support from a professional* approach. According to the interviews, gardens that are managed by professionals do not have governance problems. This supports the views of scholars who argue that 'top-down' governance structures provide more expertise in organization and management (Palamar, 2010; Follmann and Viehoff, 2015; Austin et al., 2006; Ghose et al., 2014). Some have argued that not having professional coordination can be a barrier to success for community projects (Fox-Kämper et al., 2018). However, in this study community gardens that operate without any professional help (highest autonomy level) do not indicate low perceptions of success.

Another problem is lack of experience and knowledge about gardening. In this case gardens' productivity as biophysical commons might be low even if participation is high. On the other hand, their value and productivity as intellectual commons increases when less experienced members take gardening classes and learn from others. Recognizing community gardens as social, cultural and intellectual commons affects their organization and management and creates a space for new incentives to be applied to promote participation.

Community gardens represent food systems that embed multiple interconnected socioeconomic, cultural, political, and ecological processes (Lang et al., 2009). Socioeconomic and demographic characteristics of the gardeners influence their values, motivations to garden and perceptions of the success. The interviews with key informants did not provide sufficient data regarding participants' demographics and socioeconomic characteristics because not all gardens keep these records. Therefore, the Census data were used to analyze a spatial distribution of the population in Austin by census block groups to determine any patterns between the gardens' locations and characteristics of the population, such as income, age, education and race and ethnicity (Figures 42-49).

Spatial anlysis did not show much racial and ethnic diversity. Most of the gardens with the highest perceptions of success and high seasonal changes in NPP are located in areas that are predominantly White or Hispanic populations (Figures 42-43). Three out of fifteen gardens are located in block groups with predominantly Black populations (Figure 44). However, one of these (Homewood Hights Community Garden) stated in the interview that its members are predomnately White. Two gardens out of fifteen gardens are located in the areas of predominantly Asian residents (Figure 45). One of them – the Lamplight Community Garden – indicated in its mission statement "appreciation of human and cultural differences.” The analysis of the total population revelaed that community gardens with high socio-ecological performance are located in the block groups with the lowest populations (Figure 46). Examination of education attainment shows that most of these community gardens are located within the block groups where at least half of the population has a high degree (college, Master’s or Doctorate) (Figure 47).

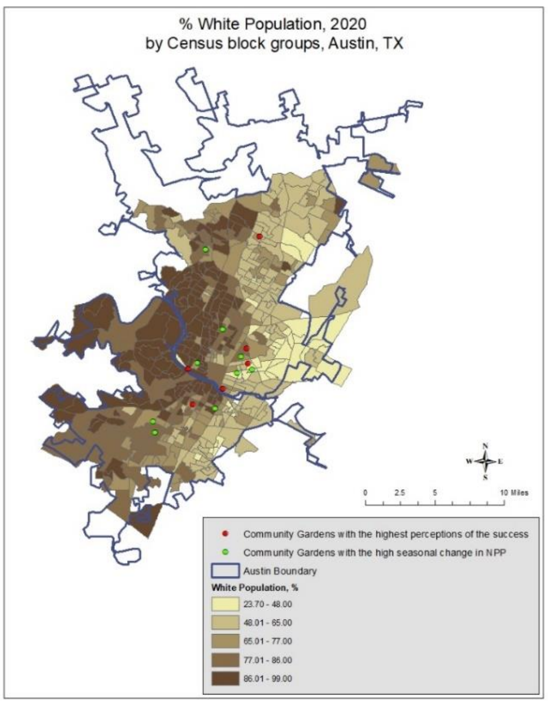


Figure 42: White population in Austin by census block groups, 2020 estimates.

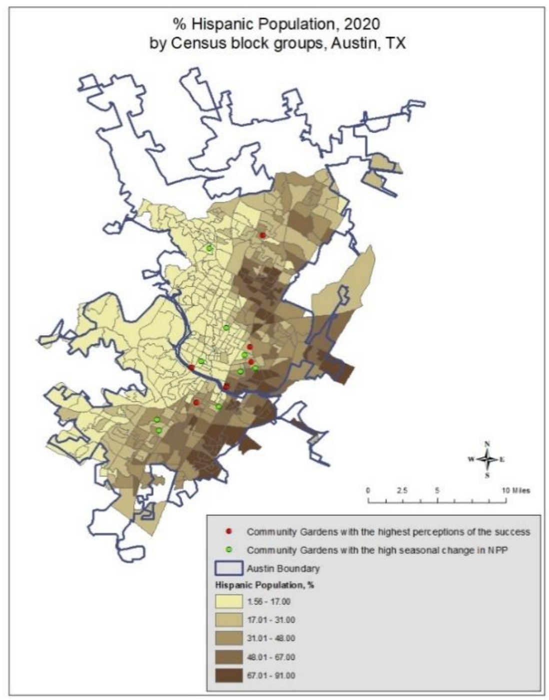


Figure 43: Hispanic population in Austin by census block groups, 2020 estimates.

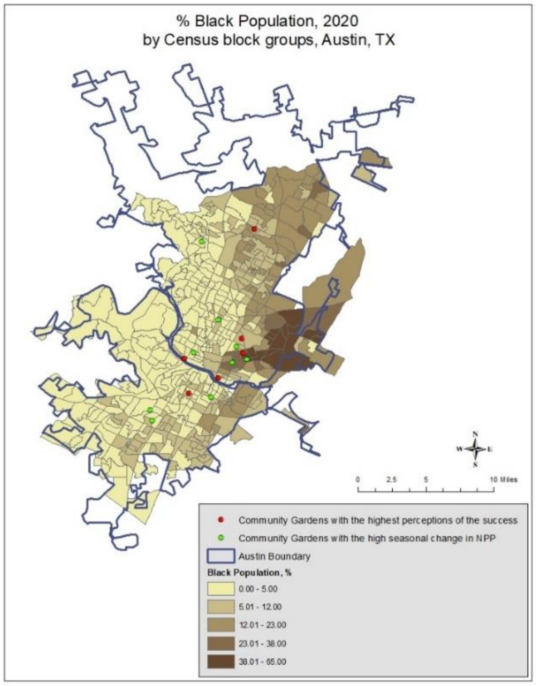


Figure 44: Black population in Austin by census block group, 2020 estimates.

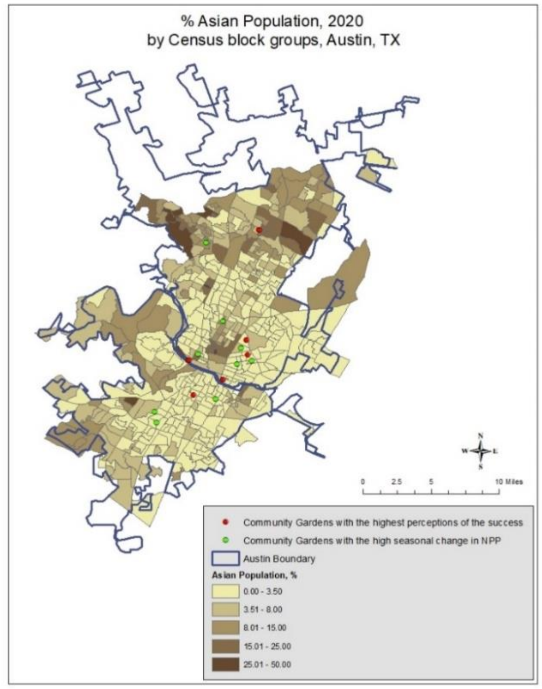


Figure 45: Asian population in Austin by census block group, 2020 estimates.

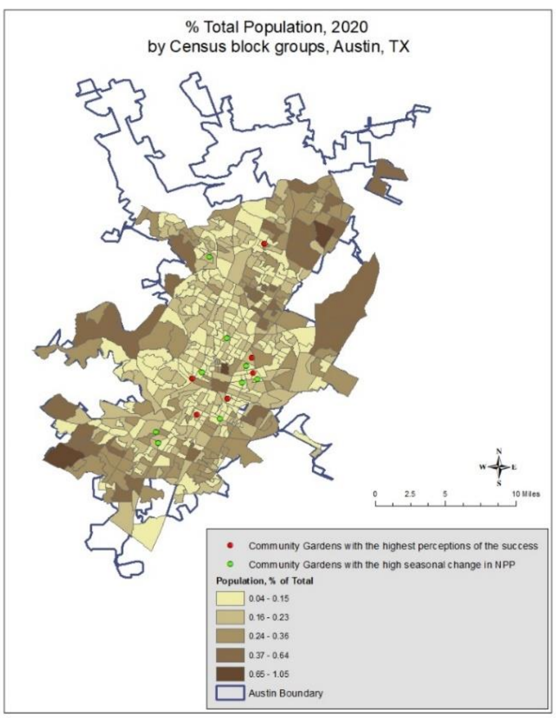


Figure 46: Populations of census block groups in Austin, 2020 estimates.

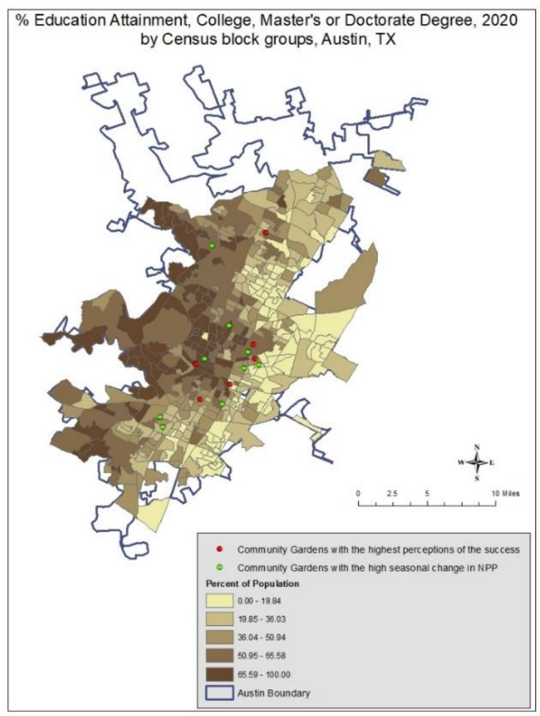


Figure 47: College education or more by block group, 2020 estimates.

Community gardens that show high social and ecological performances are located predominantly in the block groups where the median annual household income is lower than the average value for the analyzed area (Figure 48). Most of these gardens belong to the block groups with up to 35 percent of population living in poverty (Figure 49). These economic factors can motivate people to get involved in community gardening

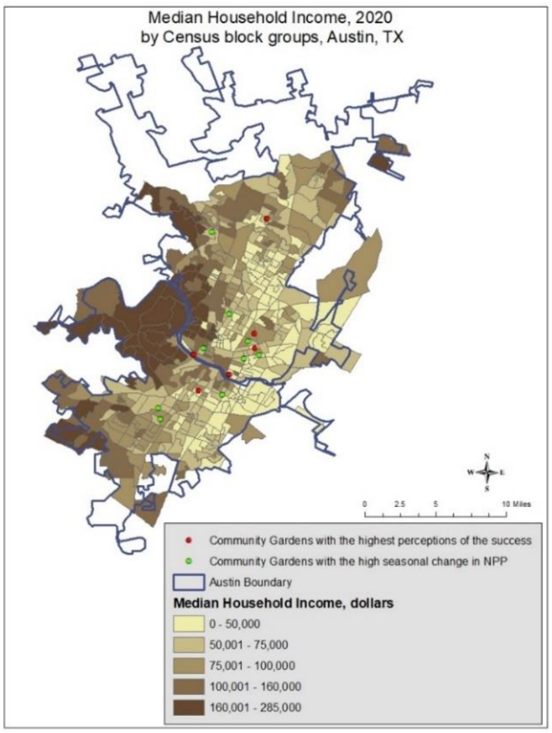


Figure 48: Median household income by census block group in Austin, 2020 estimates.

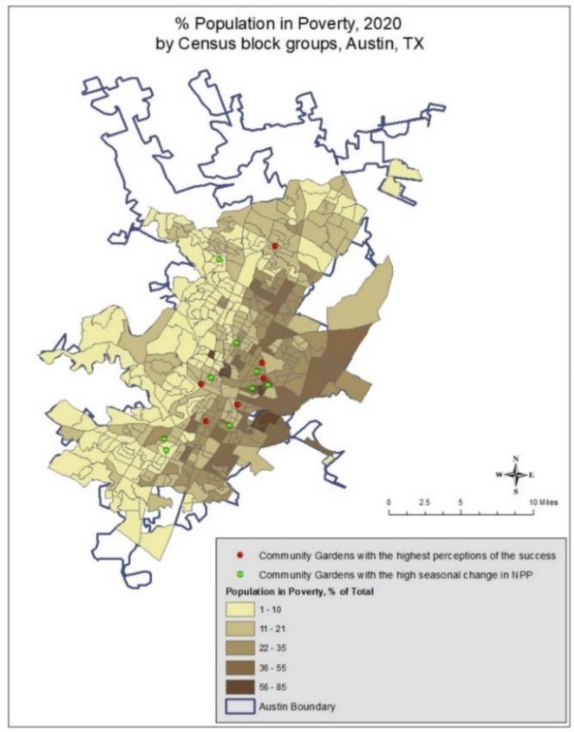


Figure 49: Poverty percentages by census block groups in Austin, 2020 estimates.

for food production. Consequently, residents of these block groups are interested in the outcomes of gardening, which affects the level of their participation. All community gardens with high social and ecological performances have either stable or increasing participation. Socio-economic and demographic attributes help to understand the factors that influence community members' involvement in collective action, their values and goals. These attributes of the community, the specific biophysical characteristics of the gardens, and the rules and regulation in use affect the participation, productivity and perceptions of success and influence the effectiveness of the community gardens' governance.

Community Gardens' Governance: Successful Management of the Commons

This dissertation contributes to the Diverse Economies scholarship by arguing that community gardens represent 'community economies' – "spaces of decision making where we recognize and negotiate our interdependence with other humans, other species, and our environment" (Gibson-Graham et al., 2013, p. 54). The Diverse Economies framework describes principles of successful governance of commons that involve their responsible use with regard to each other and the environment. Scholars view the commons and community relationship as one does not exist without the other (Federici and Caffentzis, 2014; De Angelis, 2010). Community economies are guided by these principles of 'ethical action' as they advocate for social and ecological interdependency (Gibson-Graham, 2006). The Diverse Economies framework discussed the importance of 'ethical action' in economy, which includes the following (Gibson-Graham et al., 2013, p. 53):

- surviving together well and equitably,
- distributing surplus to enrich social and environmental health,
- encountering others in ways that support their well-being as well as ours,
- consuming sustainably,
- caring for – maintaining, replenishing, and growing – our natural and cultural

commons, and

• investing our wealth in future generations so that they can live well.

Scholars apply design principles of successful commons governance developed by Elinor Ostrom that define the effective management of biophysical commons (commons as a natural recourse) (Table 22). In the Diverse Economies framework, Gibson-Graham's principles of ethical action define the successful management and organization of social, cultural, intellectual and biophysical commons.

Table 22: Ostrom's 8 design principles of successful governance of common-pool resources (Ostrom, 1990).

	Description
1	Define clear group boundaries
2	Match rules governing use of common goods to local needs and conditions
3	Ensure that those affected by the rules can participate in modifying the rules
4	Rule-making rights of community members are respected by outside authorities
5	A system, carried out by community members, for monitoring members' behavior
6	Use graduated sanctions for rule violators
7	Provide accessible, low-cost means for dispute resolution
8	Build responsibility for governing the common resource in nested tires

Ostrom's design principles provide practical recommendations on how to organize the governance of natural recourses to avoid their ineffective use and depletion. These design principles suggest aspects of governance that lead to more effective implementation of rules and regulations and subsequent monitoring. The principles of ethical action describe the ideology that creates a perspective that, if applied to governance, would produce a just and effective commoning. The management that is built upon this mindset is concerned with the social inclusion of minorities, food security, sustainable production and consumption, and environmental protection. These ethical dynamics investigate how individual and group decisions influence the direction in which community economies evolve (Gibson-Graham, 2008). They do not provide organizational and management techniques; rather, they suggest the way to approach commoning in terms of goals and desired outcomes. They ask community members to critically evaluate their use of commons and choose an approach that would mutually benefit the society and nature. Community gardens in Austin with the highest seasonal changes in carbon sequestration as well as gardens with the highest perceptions of the success demonstrate the use of these principles of ethical action. Ethical dynamics are applied to the social capital, knowledge and natural space of these community gardens (Figure 50) because not only natural resources can be commoned but intellectual, social, and cultural recourses are also subjects of commoning (Gibson-Graham, 2008).

Interviews with community gardens' representatives did not reveal sufficient evidence of *caring for – maintaining, replenishing, and growing –* ***cultural*** *commons*. However, other principles of ethical action received sufficient evidence from most of the key informants' interviews. Social commons associated with community gardens (social inclusion, community building, social exchange, networking, and participation in charity) reflect the principles of *surviving together well and equitably* and *encountering others in ways that support their well-being as well as ours.* Sustainable, community-based agriculture and organic food production (biophysical commons) include the principles of *caring for – maintaining, replenishing, and growing – our natural commons, consuming sustainably* and *surviving together well and equitably.* Caring for natural commons is also performed through the exchange of knowledge. Environmental education (intellectual commons) allows *investing our wealth in future generations so that they can live well.* The principle of *distributing surplus to enrich social and environmental health* is achieved through produce donation to food banks and other charities (Figure 50).

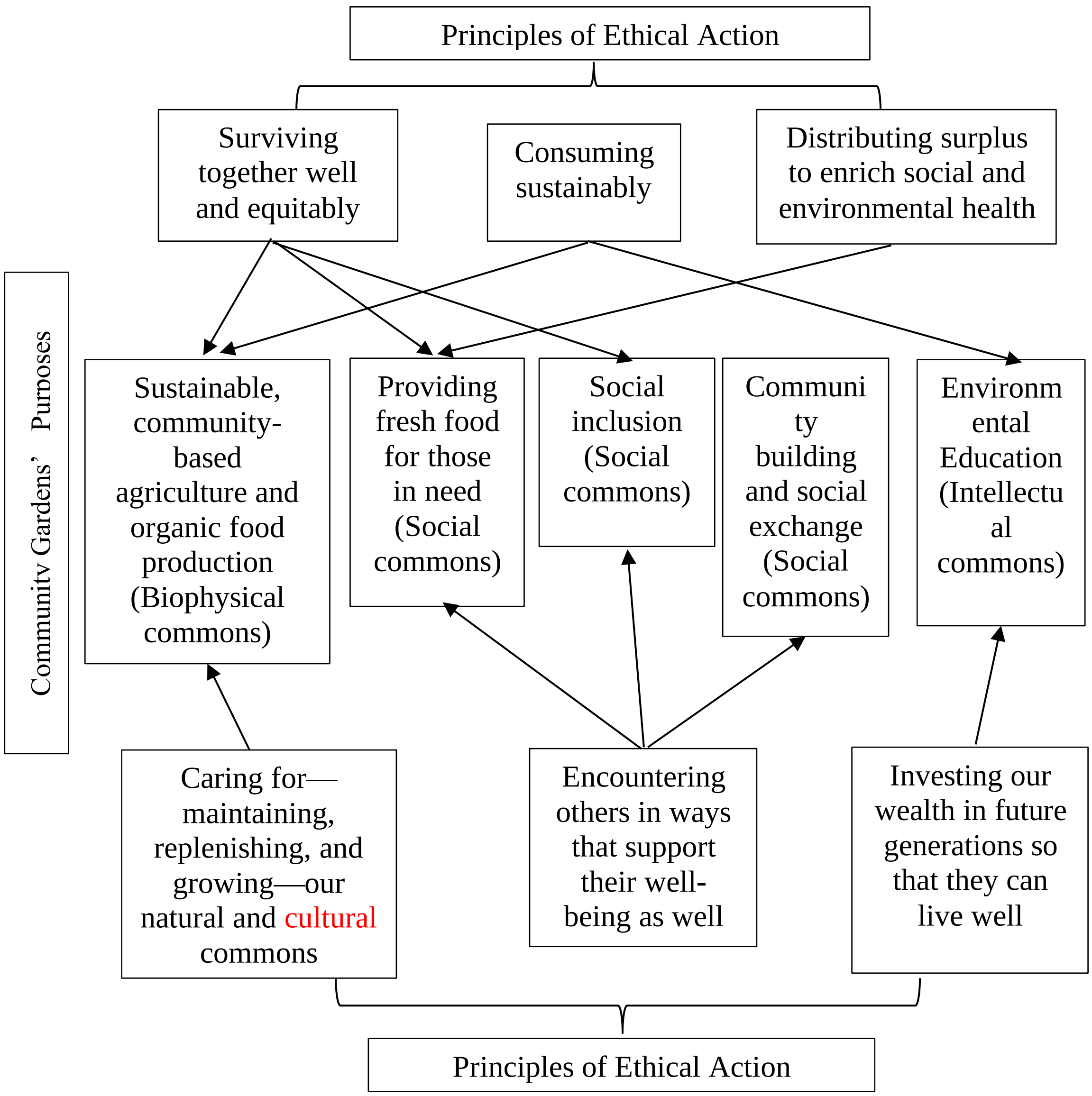


Figure 50: The principles of ethical action incorporated in community gardens' purposes

Community gardens in Austin appear to be less aware or less concern with the ecological services related to gardening (biodiversity, microclimate regulation, filtration of atmospheric particulates, rainwater retention, noise attenuation, carbon sequestration). Only three community gardens mentioned biodiversity as one of their goals. One of the purposes of this research was to draw community members' attention to the environmental aspect of gardening and potential ecological benefits resulted from the produced biomass by estimating carbon sequestration as an example of vegetation's productivity. Ecological services can represent an additional motivation to participate in community gardening.

The analysis of community gardens in Austin revealed that the highest measurements of the social and ecological performance were associated with 'bottom-up' governance structures where community members are in charge of decision-making and management. The diverse economies scholarship also argues that community members should play an active role in commons' management and governance. The successful governance of community gardens depends on the participants' commitment to care for them, which is one of the fundamental principles of ethical action. The diverse economies framework also stresses the interconnectedness of different commons and their communities (Gibson-Graham et al., 2013). Thus, biophysical commons in community gardens (soil, vegetation, atmosphere) are affected by other biophysical commons, intellectual (environmental knowledge, experience in gardening, knowledge related to management and organization) and social (cooperation, networks, participation) commons. This echoes the UPE argument that political, social, economic, cultural, and ecological factors affect nature in the city but also are affected by it (Classens, 2015). As a result, those who manage and use specific types of commons are also responsible for all the related commons. Effective management of the commons is important for their survival and flourishing.

Policy Implications and Recommendations

Including ecological services, such as carbon sequestration, in their mission statements would open possibilities for community gardens to collaborate with local non-profit environmental organizations. The meaning of a community garden goes beyond representing a local food movement. Conceptualization of community gardens as community socio-environmental projects would extend their network systems and provide more possibilities for potential sources of funding and expertise. A few community gardens in Austin indicated a shortage of funding. Some gardens experience problems with the governance and would benefit from the professional expertise. Environmental aspect of community gardening can be used to establish partnership with various environmental agencies in Austin:

1) Green Corn Project, a volunteer-run organization dedicated to educating and assisting communities in Central Texas in growing organic food. Green Corn Project conduct gardening workshops to promote bio-intensive methods like double-digging, composting, hexagonal spacing of plants, and companion planting. It views gardening as a source of food, education, and a sense of accomplishment and pride. This organization also provides an avenue for potential members recruitment (five interviewed community gardens in Austin experience a decrease in participation).

2) The EarthShare of Texas, a nonprofit organization that distributes funds to

qualifying charities to pursue positive environmental and health impacts. It represents a collaboration of different environmental organizations, public institutions, and businesses advocating for environmental protection, air quality improvement, wildlife rehabilitation, green infrastructure and other aspects of sustainable development.

3) Austin Area Garden Center Inc. promotes community education regarding horticulture and nature through gardening workshops, lectures and field trips.

4) Environment Texas, a non-profit organization that promotes core environmental values, such as clean air, clean water and renewable clean energy.

Some of the gardens in Austin included healthy lifestyle and environmental knowledge in their list of goals and values. This research suggests including the following goals in community gardens' mission statements: "*One of the goals of this community garden is to pursue positive environmental and health impacts, conserve and sustain a healthy environment, and promote core environmental values through organic food production.*"

Remote sensing data were also used to identify general city-scale spatial patterns. For urban food policymakers and planners, and program officials, spatial analysis of socio-economic and demographic characteristics of the population helps to reveal the areas that would benefit from community gardening. This research suggests the need for ecological visioning and messaging for community gardens' planners that would appeal to a diverse population and provide an additional motivation for participation in community gardening. Emphasizing environmental values, such as carbon regulation, in urban food production would integrate community gardening in the sustainability dialog, and possibly, a global warming dialog. Community gardeners need to include "sustainability" and "ecological services" in the language they use to advertise their gardens to attract more stakeholders. They also need to emphasize "racial and ethnic diversity" among their values to enrich their ethnic profiles. Commitment to ethnic diversity can help to improve food accessibility and equality, establish partnerships with NGOs, increase minority representation, social cohesion, and sense of community. Festival Beach Community Garden in Austin is a great example of a community that takes care of its cultural commons through networking and collaboration with non-profit organizations like Multicultural Refugee Coalition (MRC).

CHAPTER VII

CONCLUSIONS

Community gardens are spaces of food production that belong to both natural and social worlds and represent a UPE's concept of 'socionature'. This dissertation investigated the relationships between the community gardens' governance, social outcomes of gardening (gardeners' perceptions of their success) and gardens' biophysical productivity (carbon sequestration). This study analyzed community gardens as socio-ecological systems using Ostrom's SES framework that provides a set of variables serving as codes for the deductive coding method of analysis. This research contributes to the Diverse Economies framework by arguing that community gardens represent several kinds of commons: biophysical, social, cultural, and intellectual commons that are interdependent. Biophysical commons in community gardens (soil, vegetation, atmosphere) are affected by other biophysical commons, intellectual (environmental knowledge, experience in gardening, knowledge related to management and organization) and social (cooperation, networks, participation) commons. These types of commons co-exist to create a community economy where decision making recognizes interdependence between humans and the environment (Gibson-Graham et al., 2013).

Community gardening involves the production of biomass. Community gardens generate social, cultural and intellectual commons through the interaction with and transformation of natural capital (biophysical commons). The productivity of gardening depends on the cumulative input of ecological factors (sunlight, rain, and soil), the application of seeds, tools, and fertilizer, and the human factor (volunteer efforts of community gardeners). Production of biomass in community gardens requires human effort, time management, gardening skills, environmental knowledge, and commitment to the collective action. These factors depend on how the garden's activities are organized and governed. Governance approach determines how the garden is managed and operated. Therefore, the effective production and use of biophysical commons depends on the social and intellectual commons that are guided and controlled by the model of governance. Consequently, successful governance improves gardens' socio-ecological performance. This research argues that the efficacy of community gardens depends on their commitment to the principles of "ethical action" that should be incorporated in gardens' goals, values and governance. The Diverse Economies, UPE, and SES frameworks were used to understand how the rules and regulation in use, the specific biophysical characteristics of the gardens, and the attributes of the community affect the participation, productivity, and perceptions of success.

Criteria have been applied to determine the model of governance of community gardens in Austin (Figure 8). The analysis revealed that the majority of the gardens (13 out of 26) follow the governance approach: *'bottom-up': projects managed and run by local communities with informal support from a professional*. An important external non-profit organization that provides financial support and advice to community gardens in Austin is the Sustainable Food Center (SFC) – most of the gardens with this governance structure collaborate with SFC. Eight community gardens employ a *'top-down': projects managed by professionals but run by paid workers/volunteers* approach. These gardens are governed by senior centers, churches, community associations and educational centers (Appendix I). Five community gardens function without external support and utilize the governance structure *‘bottom-up’: projects managed and run by local communities*. There are no community gardens in Austin that hire workers to run the garden or hire professionals to help with the organization and management. Gardens with ‘top-down’ governance structures are run by volunteers. ‘Bottom-up’ community gardens receive professional assistance from schools, non-profit organizations, churches, and businesses also on a voluntary basis. This reflects a sense of community and social capital in Austin.

Social outcomes were measured by the level of gardeners’ satisfaction and perceptions of their success. The gardeners were asked to indicate their perceptions of the success of their community gardens by checking the appropriate box on the LIKERT scale from ‘unsuccessful’ to ‘very successful’. Four gardens indicated their level of success as Successful, but with many issues/problems. The common problem of these gardens is low participation when it comes to common duties such as taking care of garden’s common areas. Ten gardens indicated their level of success as ‘Successful, but with a few issues/problems’. These gardens indicated that they experience issues with organization and management. Most of the gardens (twelve) indicated their level of success as ‘Very Successful’. No key informants considered their community gardens to be ‘Unsuccessful’ or ‘Unsuccessful, but with a potential for improvement’. Human factors can affect these results, such as specific roles of some of the key informants as PRs and managers. The analysis of the SES variables shows that the highest perceptions of the success are associated with big-size gardens that have more than 50 members and gardens that experience a stable or increasing participation. The oldest gardens in Austin have high perceptions of their success.

Ecological services provided by gardens as green spaces were estimated through net primary productivity (NPP), which is a measurement of carbon sequestration. One of the main factors contributing to carbon sequestration is the amount of biomass that results from the gardeners' collective action. The seasonal differences in carbon dioxide uptake were analyzed by choosing a representative period for a growing and non-growing season, respectively. The seasonal difference in the NPP were calculated for each garden and two-sample t-tests were applied in to statistically compare these NPP values. The first t-test determined that there is a significant difference in carbon sequestration between two seasons (p-value = 0.001235) and the second t-test confirmed that carbon sequestration by community gardens is higher during a growing season (p-value = 0.0006173) (Table 18). Future research should compare NPP of gardens with NPP of empty lots to analyze the differences in carbon sequestration by urban agriculture and natural vegetation possibly occupying empty lots (such as, grass). Increase in NPP values depends on the three factors: PAR, LUE and NDVI. The values of PAR and LUE are based on the local climate conditions, while the values of NDVI in community gardens depend on both climate and human efforts. Increase in NDVI values might indicate increase in human participation, extended and more frequent working hours, improvement in gardening skills, and effective organization and management.

Participation is a fundamental aspect of community gardening because it creates both physical objects (individual plots, functioning zones, and biomass) and social capital (networks, socio-ecological memory, social exchange). The level of participation reflects garden's value to the community. Participation in common duties, such as maintenance of common areas and composting, was indicated as the most common problem among the interviewed community gardens. Effective management strategies and better organization represent a solution to this problem.

This study contributes to the existing scholarship by analyzing the success of community gardens and their ecological performance as a function of their governance and the spatial interaction of actors with socio-economic and environmental conditions. Gardeners' perceptions of their success and their levels of satisfaction depend on whether they were able to achieve their goals. The most common goals associated with 'very successful' gardens include sustainable, community-based agriculture and organic food production and community building and social exchange (Figure 38). The analysis of key-informant interviews did not reveal any associations between the perceptions of success and socio-demographic characteristics of the gardeners, such as ethnic composition and age. Most of the interviewed gardens do not keep records on their members' race and ethnicity, age or level of income. This analysis was conducted during COVID-19 pandemic, which also affected the collection of data. Spatial analysis of census data (2020 estimations) reveals certain patterns and shows that most of the community gardens with the highest perceptions of success and high seasonal changes in NPP are located in areas with a high percent of White or Hispanic population (Figures 42-43), median annual household income lower than the average value for the analyzed area (Figure 48), and with up to 35 percent of population living in poverty (Figure 49). These factors can motivate people to get involved in community gardening for a food production, which resulted in high socio-ecological productivity.

The analysis of community gardens in Austin revealed that the highest measurements of the social and ecological performance are associated with 'bottom-up' governance structures where community members are in charge of decision-making and management. A predominant model of governance that is associated with high socio-ecological performance is *'bottom-up': projects managed and run by local communities with informal support from a professional*. This model is utilized by community gardens with the highest seasonal increases in NPP and highest perceptions of their success. This approach recognizes community members' involvement in the management of their garden, but also incorporates assistance from professional organizations. Thus, gardeners create ties with non-profit organizations, government agencies, and businesses to obtain materials, resolve land-use conflicts, or acquire other resources, like information and advocacy support, which benefits the governance by providing external expertise through extended networks. This finding supports the previous research, which argues that collaboration with the government and NGOs can positively affect collective action and ecological conditions by providing stability and longevity to the garden (Palamar, 2010; Austin et al., 2006). According to the analysis of the interviews, this governance approach is also the one that incorporates most of the Gibson-Graham's principles of successful governance.

The Diverse Economies framework proposes principles of successful governance of commons that go beyond the consideration of commons as natural resources. These principles of ethical action consider the social value produced by the human interaction and involve the responsible use of commons with regard to each other and the environment. This research contributes to the scholarship by expanding on the discourse about community gardens as commons. It argues that the productivity of different types of commons that are associated with community gardening depends on the gardens commitment to the principles of "ethical action" that can be incorporated in gardens' goals, values and governance. Most of the principles of ethical action are incorporated in the governance of community gardens that show the highest seasonal change in carbon sequestration (>1 kg) and gardens that have the highest perceptions of the success. Some of the principles of ethical action were less present in the governance of the community garden with lower perceptions of the success and low seasonal changes in NPP, for example, the principle of *distributing surplus to enrich social and environmental health* and the principle of *investing our wealth in future generations so that they can live well*. The analysis of interviews also did not reveal sufficient evidence of *caring for — maintaining, replenishing, and growing – cultural commons* among most of the gardens. By including environmental aspects of community gardening in their mission statements, gardeners can establish partnership with various environmental agencies in Austin, expand their funding possibilities and promote their membership. Informal support from external organizations is an asset that helps to achieve successful governance.

To conclude, this research: 1) starts a discourse on community gardens as social, cultural and intellectual commons, and adds to Elinor Ostrom's and Gibson-Graham's work on commoning, 2) illustrates why social and ecological outcomes of community gardens are co-dependent and need to be analyzed in tandem, 3) provides a case study that investigates the use of the principles of 'ethical action' in community gardens in Austin, 4) proposes new variables to the SES framework that are specific to community gardening analysis, and 5) provides specific recommendations to improve organization and management of community gardens in Austin. Future research should be conducted to investigate the relationships between different socio-demographic characteristics of the gardeners and other socio-ecological measurements of gardens’ productivity. Furthermore, analysis of how the principles of successful governance can be incorporated in community gardens’ agendas to increase members’ participation in creation of biophysical, social, cultural and intellectual commons should be conducted.

APPENDIX SECTION

Appendix A

The Questionnaire

1. What is the purpose of your community garden? What are your primary and secondary goals? (For example, your goals might be access to fresh food, saving money, providing fresh produce for those in need, promoting environmental education, creating a meeting place for the social exchange, etc.)

2. When did your community garden open?

3. Who owns the land on which your community garden operates? (Is it publicly or privately owned?)

4. How is your community garden governed? In other words, who is responsible for the decision-making in your garden and who is involved in its management? (For example, you may have a group of selected or elected people who make all the decisions, or each gardener is involved in management. You might instead have an external manager – for example, a non-government organization – who conducts the management.)

5. Please describe some management techniques or strategies that you use to achieve the goals of your community garden. (For example, if the purpose of your community garden is to produce food for disadvantaged and vulnerable population groups, then your strategies may include collaboration with food banks, participation in a charity, etc.)

6. How many plots are in your garden? What is the approximate total area of your garden?

7. Do you receive funding from external sources? Would you please name the sources of your funding? (For example, support from a particular non-governmental organization, a sponsor, government, or gardeners themselves.)

8. Is your garden open to the general public? Is membership eligibility defined by a specific community or neighborhood? Who can join? Do you have a waiting list for access to a garden plot?

9. How many members or gardeners do you currently have? How many people (in addition to the gardeners) participate in any other aspect of your community garden? Is participation growing or decreasing?

10. Do you have a sense of the demographics of your participants? What is the age distribution of members of your community garden? Can you describe, in general terms, the ethnic composition of your community garden? Are any ethnic groups prevalent in the membership or are participants diverse (ethnically speaking)?

11. Do you advertise your community garden? If yes, where and how do you advertise?

12. What type of vegetables/plants are grown in your community garden? Are any specific products dominant in the garden's production or do people choose to grow a wide array of plants with significant variation?

13. Please identify any issues, problems, or concerns that you are experiencing in your community garden. (For example, insufficient funding, insufficient space, insufficient participation, or too much unmet demand for space)

14. Please indicate your perception of the success (your personal measure of success) of your community garden by checking the appropriate box on the scale below. (For example, you may consider your garden successful if it serves its purpose(s), achieves its goals, has stable or growing participation, has sufficient funding, etc.)

Unsuccessful	Unsuccessful, but has a potential for improvement	Successful, but with many issues/problems	Successful, but with a few issues/problems	Very successful

Appendix B

Recruitment Email Message

To: The list of community gardens
From: Daria Andrievskikh (d_a292@txstate.edu)
BCC: Individually targeted messages only
Subject: Research Participation Invitation: The Models of Governance of the Community Gardens in Austin

This email message is an approved request for participation in research that has been approved by the Texas State Institutional Review Board (IRB).

Dear Community Garden Representative,

My name is Daria Andrievskikh, I am a PhD student at Texas State University – San Marcos, and I am conducting a research study that attempts to analyze the different models of governance of the community gardens in Austin. I am reaching to you with several questions because you are listed as a contact person in your community garden on the following web page: https://communitygardensaustin.org/gardens/. These questions are related to the management techniques and strategies that community gardens use to serve their purposes. Your answers will help to determine similarities and differences in the purposes of the community gardens in Austin, as well as to identify the common issues and problems that community gardens in Austin encounter. This questionnaire will also help to create a socio-economic profile of the community gardens in Austin by analyzing the socio-economic and demographic characteristics of the participants, such as age, ethnicity, and economic situation.

Participation is voluntary. Your participation in this research is highly valued. Participating in this interview sheds light on the management strategies used by the community gardens and could result in identifying the most effective and beneficial techniques and strategies.

You may choose to complete the questionnaire at your convenience or to answer the questions via the phone. If you choose to complete the questionnaire at your convenience, you will receive a reminder in three to four weeks. If you prefer to answer the questions over the phone, we will schedule a phone call at your convenience. It will take about 30-40 minutes to answer the questions. Your responses are anonymous unless you wish your name to appear in a future academic publication.

Please consider participation in this survey, your contribution is highly valued!

Thank you for your time.

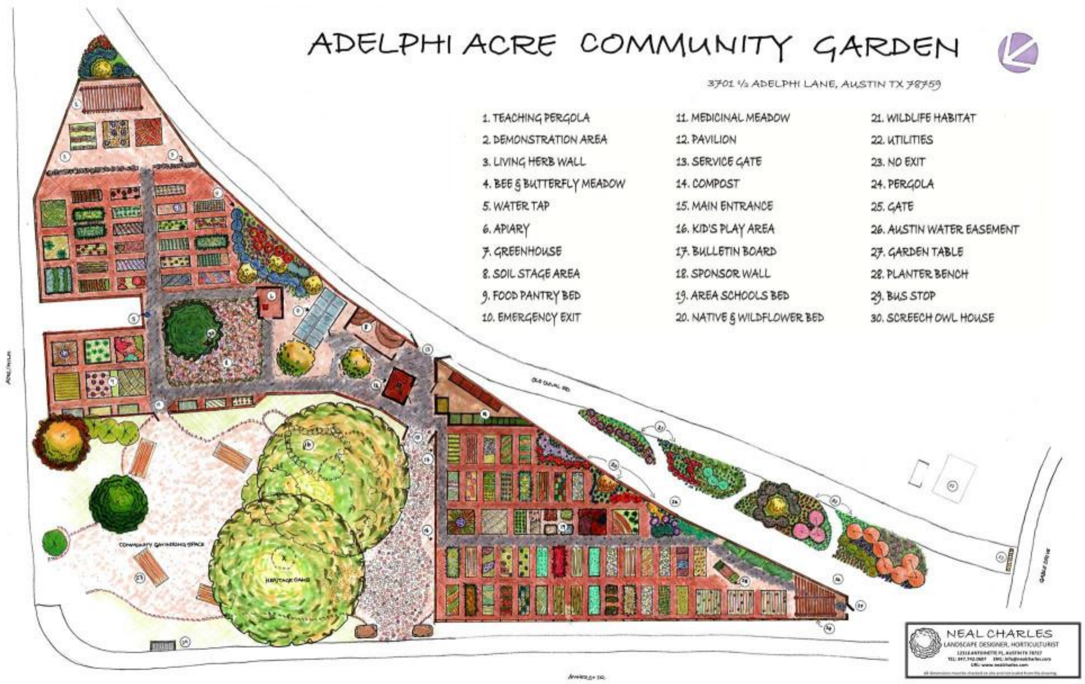
Daria

To participate in this research or ask questions about this research please contact me at: Daria Andrievskikh, d_a292@txstate.edu, (862)505-86-13.

This project IRB: #6416 was approved by the Texas State IRB on March 18, 2019. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Denise Gobert 512-716-2652 – (dgobert@txstate.edu) or to Monica Gonzales, IRB Regulatory Manager 512-245-2334 - (meg201@txstate.edu).

Appendix C

Adelphi Acre Community Garden: A Design Plan



Appendix D

The Areas of Community Gardens Participated in This Analysis

The list of Community Gardens in Austin, TX	Area (square meters)	Area (acres)
Adelphi Acre Community Garden	4,743	1.172
Alamo Community Garden	1,341	0.331
Asian American Resource Center Program Garden	918	0.227
Cherry Creek Community Garden	927	0.229
Clarksville Community Garden	324	0.080
Deep Eddy Community Garden	4,140	1.023
Emerald Wood Community Garden	882	0.218
Faith Church Community Garden	495	0.122
Festival Beach Community Garden	5,859	1.448
Garden of Eatin' at South Austin Senior Activity Center	1,701	0.420
Gardens at Gus Garcia Recreation Center	1,521	0.376
Grow Together Community Garden at Gateway Church	1,935	0.478
Good Soil Community Garden	207	0.051
Homewood Heights Community Garden	621	0.153
Hyde Park Community Garden	1,350	0.334
Labyrinth Community Garden at St. Johns Episcopal Church	1,107	0.274
Lamplight Community Garden	6,138	1.517
Mueller Community Garden	2,097	0.518
Patterson Park Community Garden	2,709	0.669
PEAS School and Community Farm and Urban Orchard	1,035	0.256
Rollingwood Community Education Garden	459	0.113
South Austin Community Garden	2,142	0.530
St. David's Foundation Community Garden	2,367	0.585
Sunshine Community Gardens	16,911	4.179
Unity Park Community Garden	1,548	0.383
Windsor Park Community Garden	1,602	0.396

Appendix E

PlanetScope Data Acquisition Records

The list of Community Gardens in Austin, TX	t1		t2	
	Date of Image Acquisition	Time of Image Acquisition	Date of Image Acquisition	Time of Image Acquisition
Adelphi Acre Community Garden	July 27, 2018	16:46	May 26, 2019	17:00
Alamo Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Asian American Resource Center Program Garden	July 27, 2018	16:37	May 26, 2019	17:00
Cherry Creek Community Garden	July 24, 2018	16:41	May 26, 2019	17:00
Clarksville Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Deep Eddy Community Garden	July 24, 2018	16:41	May 26, 2019	17:00
Emerald Wood Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Faith Church Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Festival Beach Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Garden of Eatin' at South Austin Senior Activity Center	July 24, 2018	16:41	May 26, 2019	17:00
Gardens at Gus Garcia Recreation Center	July 27, 2018	16:37	May 26, 2019	17:00
Grow Together Community Garden at Gateway Church	July 27, 2018	16:46	May 26, 2019	17:00
Good Soil Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Homewood Heights Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Hyde Park Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Labyrinth Community Garden at St. John's Episcopal Church	July 27, 2018	16:37	May 26, 2019	17:00
Lamplight Community Garden	July 27, 2018	16:46	May 26, 2019	17:00

Mueller Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Patterson Park Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
PEAS School and Community Farm and Urban Orchard	July 24, 2018	16:41	May 26, 2019	17:00
Rollingwood Community Education Garden	July 27, 2018	16:37	May 26, 2019	17:00
South Austin Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
St. David's Foundation Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Sunshine Community Gardens	July 27, 2018	16:37	May 26, 2019	17:00
Unity Park Community Garden	July 27, 2018	16:37	May 26, 2019	17:00
Windsor Park Community Garden	July 27, 2018	16:37	May 26, 2019	17:00

Appendix F

ESI and NDVI Values Obtained from the Remote Sensing Data

Community Gardens in Austin, TX	t1		t2	
	ESI	NDVI (sum)	ESI	NDVI (sum)
Adelphi Acre Community Garden	0.41	213.285	0.9	166.86
Alamo Community Garden	0.43	64.407	0.84	44.07
Asian American Resource Center Program Garden	0.26	10.742	0.8	45.97
Cherry Creek Community Garden	0.48	42.722	0.92	53.64
Clarksville Community Garden	0.50	16.091	0.87	19.6
Deep Eddy Community Garden	0.61	166.579	0.86	291.32
Emerald Wood Community Garden	0.36	41.662	0.92	29.95
Faith Church Community Garden	0.43	23.945	0.83	27.17
Festival Beach Community Garden	0.38	328.535	0.87	387.05
Garden of Eatin' at South Austin Senior Activity Center	0.43	75.91	0.92	56.99
Gardens at Gus Garcia Recreation Center	0.44	80.804	0.84	86.99
Grow Together Community Garden at Gateway Church	0.41	109.685	0.9	96.7
Good Soil Community Garden	0.3	7.638	0.81	9.63
Homewood Heights Community Garden	0.51	32.151	0.85	42.19
Hyde Park Community Garden	0.43	69.981	0.83	97.23
Labyrinth Community Garden at St. John's Episcopal Church	0.28	50.425	0.81	60.87
Lamplight Community Garden	0.27	180.843	0.81	236.07
Mueller Community Garden	0.24	57.508	0.71	72.43
Patterson Park Community Garden	0.34	124.691	0.84	168.82
PEAS School and Community Farm and Urban Orchard	0.29	50.698	0.93	63.27
Rollingwood Community Education Garden	0.45	10.54	0.83	15.12
South Austin Community Garden	0.47	120.26	0.88	122.85
St. David's Foundation Community Garden	0.61	135.197	0.81	159.18
Sunshine Community Gardens	0.34	875.4	0.81	736.4
Unity Park Community Garden	0.43	70.067	0.81	71.9
Windsor Park Community Garden	0.26	74.003	0.76	90.34

Appendix G

Calculated Values of LUE and NPP

Community Gardens in Austin, TX	t1		t2		Seasonal difference (g)
	LUE (g/MJ)	NPP (g)	LUE (g/MJ)	NPP (g)	
Adelphi Acre Community Garden	1.08063	891.9619	3.493	2150.687	1258.725
Alamo Community Garden	1.10438	275.2711	3.343	543.6818	268.4107
Asian American Resource Center Program Garden	0.9025	37.5183	3.243	550.1926	512.6743
Cherry Creek Community Garden	1.16375	192.4076	3.542	701.2519	508.8443
Clarksville Community Garden	1.1875	73.9482	3.418	247.2143	173.2661
Deep Eddy Community Garden	1.31813	849.7434	3.393	3647.591	2797.847
Emerald Wood Community Garden	1.02125	164.6581	3.542	391.5454	226.8872
Faith Church Community Garden	1.10438	102.3393	3.318	332.6888	230.3495
Festival Beach Community Garden	1.045	1328.6448	3.418	4881.851	3553.207
Garden of Eatin' at South Austin Senior Activity Center	1.10438	324.4341	3.543	745.0474	420.6133
Gardens at Gus Garcia Recreation Center	1.11625	349.0642	3.343	1073.176	724.112
Grow Together Community Garden at Gateway Church	1.08063	458.7047	3.493	1246.383	787.678
Good Soil Community Garden	0.95	28.0811	3.268	116.1434	88.06228
Homewood Heights Community Garden	1.19938	149.2315	3.368	524.3729	375.1414
Hyde Park Community Garden	1.10438	299.0939	3.318	1190.553	891.4593

Labyrinth Community Garden at St. John's Episcopal Church	0.92625	180.7528	3.268	734.1275	553.3747
Lamplight Community Garden	0.91438	639.9367	3.268	2847.141	2207.205
Mueller Community Garden	0.87875	195.5711	3.019	806.8648	611.2938
Patterson Park Community Garden	0.9975	481.3478	3.343	2082.695	1601.347
PEAS School and Community Farm and Urban Orchard	0.93813	184.0613	3.568	832.9727	648.9114
Rollingwood Community Education Garden	1.12813	46.0159	3.318	185.14	139.124
South Austin Community Garden	1.15188	536.0898	3.443	1560.814	1024.724
St. David's Foundation Community Garden	1.31813	689.6593	3.268	1919.803	1230.144
Sunshine Community Gardens	0.9975	3379.3285	3.268	8881.411	5502.083
Unity Park Community Garden	1.10438	299.4615	3.268	867.1557	567.6942
Windsor Park Community Garden	0.9025	258.4684	3.144	1047.967	789.4984

Appendix H

Community Gardens with the Seasonal Changes in NPP More Than 1 Kg

Community Gardens in Austin, TX	Seasonal difference in NPP (g)	Model of Governance	Particip ation	Number of Members/Year of Establishment	Area, sq.m.
Deep Eddy Community Garden	2797.847	'bottom-up': projects managed and run by local communities	Stable	56-70/1978	4,140
Festival Beach Community Garden	3553.207	'bottom-up': projects managed and run by local communities with informal support from a professional	Stable	80/2010	5,859
Lamplight Community Garden	2207.205	'bottom-up': projects managed and run by local communities with informal support from a professional	Stable	30/2019	6,138
Patterson Park Community Garden	1601.347	'bottom-up': projects managed and run by local communities	Increasi ng	25/2006	2,709
South Austin Community Garden	1024.724	'bottom-up': projects managed and run by local communities with informal support from a professional	Increasi ng	26/1994	2,142
St. David's Foundation Community Garden	1230.144	'bottom-up': projects managed and run by local communities with informal support from a professional	Increasi ng	40/2012	2,367
Sunshine Community Gardens	5502.083	'top-down': projects managed by professionals but run by paid workers/volunteers	Stable	100/1979	16,911
Adelphi Acre Community Garden	1258.725	'bottom-up': projects managed and run by local communities with informal support from a professional	Decreasi ng	100/2015	4,743

Appendix I

Models of Governance and Ownership of Community Gardens in Austin, TX

Community Gardens	Models of Governance and Ownership		
	‘top-down’: projects managed by professionals but run by paid workers/volunteers	‘bottom-up’: projects managed and run by local communities with informal support from a professional	‘bottom-up’: projects managed and run by local communities
Adelphi Acre Community Garden		Community members	
Alamo Community Garden		Community members	
Asian American Resource Center Program Garden	Senior center		
Cherry Creek Community Garden		Community members	
Clarksville Community Garden			Community members
Deep Eddy Community Garden			Community members
Emerald Wood Community Garden		Community members	
Faith Church Community Garden		Community members	
Festival Beach Community Garden		Community members	
Garden of Eatin’ at the South Austin Senior Activity Center	Senior center		
Gas Garcia Community and Senior Serenity Garden	Senior center		
Good Soil Community Garden	Church		
Grow Together Community Garden at Gateway Church	Church		

Homewood Heights Community Garden		Community members	
Hyde Park Community Garden			Community members
Labyrinth Community Garden at St. Johns Episcopal Church		Community members	
Lamplight Community Garden		Community members	
Mueller Community Garden	Community association (apartment complex)		
Patterson Park Community Garden			Community members
PEAS School and Community Farm and Urban Orchard	Educational center		
Rollingwood Community Education Garden			Community members
The South Austin Community Gardens		Community members	
St. David's Foundation Community Garden		Community members	
Sunshine Community Gardens	Non-profit organization		
Unity Park Community Garden		Community members	
Windsor Park Community Garden		Community members	
Total	8	13	5

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