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Review Article

The value in community gardens: A return on investment analysis

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Abstract

Food production in cities is increasingly regarded as one of the building blocks for sustainable urban living, particularly as the agricultural industry faces mounting ecological and economic constraints, and the globe continues to urbanize. While substantial research exists on the qualitative outcomes of urban agriculture, few studies present these outcomes in monetary terms that align more closely with municipal decision makers' economic priorities. In response to this gap, this paper reviews the literature on outcomes of one form of urban agriculture: community gardens. We describe impacts that could be quantified and included in a monetary return-on-investment (ROI) analysis, and identify gaps in both research and data for completing such analyses. Economic impacts of community gardens can include increased property values in adjacent neighbourhoods, increasing productivity of vacant lands, the value of food produced, and food bill savings for community gardeners. Environmental impacts can include ecosystem services, protection and revitalization of vacant land, and reducing urban carbon footprints. Social impacts can include improvements in community and individual health, food security, neighbourhood safety and social cohesion, as well as educational and recreational opportunities for residents. In extant literature, outputs of community gardens are rarely quantified, and much of the research to date lacks rigorous evaluation designs. In addition, little research examines unintended consequences of community gardens, including reproduction of inequities. More research needs to be done to accurately estimate ROIs of community gardens.

Keywords: Community Gardens; return on investment; urban agriculture; food systems

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Introduction

Food systems face mounting pressure under the weight of a shrinking and aging agricultural labour force (Statistics Canada, 2011), resource depletion (Elton, 2013), climate pressures (Hansen 2015; USGCRP, 2016), population growth, and rapid urbanization. With over 80% of Canadians and more than 50% of the global population living in urban areas (World Bank, n.d.), attention is increasingly turning to the potential of food grown in cities, returning to the idea that "agriculture can and should sustain a city" (Rich, 2012, p.12).

Urban Agriculture (UA) is the production of food in urban and suburban environments. It is most commonly made up of numerous small, dispersed plots situated close to their place of consumption (Dieleman, 2016). Community gardens are one form of UA, and although they take on a diversity of forms, they are generally publicly accessible spaces used by individuals to grow food for personal consumption, sharing, donation, and/or sale (Alaimo et al., 2016).

Farmland is a finite resource quickly being consumed. In Ontario, Canada's most populous province, between 2006 and 2011, an average of 350 acres of farmland per day were lost (Ontario Food and Nutrition Strategy Group, 2017). Some of these constraints on land availability may be ameliorated by creatively making use of available spaces for production where demand exists. Community gardens generally occupy underused urban spaces, transforming these places into productive plots of land and yielding social, economic, and environmental returns. They contribute to the resilience and sustainability of increasingly vulnerable urban food systems (Barbolet, 2009) by providing access to the space (and often tools) necessary for residents to produce their own food.

Despite widespread support and enthusiasm for community gardens, research on their potential and outputs is lacking, and their diverse outputs are difficult to quantify (Guitart et al., 2012; Hou 2009; Voicu & Been 2008). While a growing body of research explores the benefits of community gardens through qualitative studies, few present them in economic or other quantitative terms. In an economic system mediated by the common exchange value of money, that which is not associated with monetary value is often regarded as economically valueless and is thereby externalized from the cost-benefit equation (Greer, 2011). Strategies for measuring community gardens' monetary value may therefore more clearly communicate their benefits to policy makers and governments (Twiss et al., 2003, Voicu & Been, 2008).

Assigning a monetary value to complex, variable results is likely to inadequately capture the extent of their impact or to unequivocally isolate community gardens as the driver of those outputs. That said, what may be an imperfect evaluation may be a springboard for recognition of their potential as a tool for community wellbeing. One method to economically describe the value of community gardens is a Return on Investment (ROI) analysis, which measures the financial gain or loss generated on an investment relative to the amount of money originally invested. It is expressed as a percentage and can be used to guide investment decision making,

with higher percentages indicating a more financially profitable investment. Using an ROI may be an effective method of conveying the value of community gardens in monetary terms, which may help to clarify their place in social, environmental, and economic wellbeing, and may therefore impact how cities invest in their operation.

This paper synthesizes the peer-reviewed and grey literature on community garden outcomes and impacts. We describe those impacts that could be quantified and included in a monetary ROI analysis and identify gaps in both research and data for completing such analyses. Finally, we outline areas for future research that would support the generation of ROI analyses on community gardens, which may then be presented to policy makers and government officials as a case for these gardens' continued expansion.

The paper is divided into three main sections around the categories of community garden outputs identified across the literature— economic, environmental, and social—with a discussion on the subcategories of each (see Table 1). Each section outlines the role that community gardens play in each subcategory, summarizing the findings of studies and what efforts have been undertaken to quantify those findings. Research gaps are identified for each category of community garden impact, highlighting key areas requiring greater study in order to translate their outputs into monetary value.

Methods

This paper surveys academic and grey literature on community garden outputs to identify the extent to which their value has been quantified in monetary form. In terms of geography, we focused our examination of available data for a return on investment analysis on Waterloo Region and Southern Ontario where research was available, incorporating literature from other locations where local information was not available.

Primo Central, an index that provides access to the University of Waterloo's available databases and collections, and Scopus were the primary sources for data collection. The references from relevant articles were also searched to identify further sources. Grey literature was collected using the same search terms, drawing primarily from Region of Waterloo Public Health publications and Canadian non-profit organization reports.

Search terms for the collected literature included the following words: community gardens, outputs, quantifying, outcomes, economic returns, and ecological economics. These terms were variously combined and paired with Boolean operators such as AND/OR to obtain results. Categories of outputs were then formed around the themes found across the literature reviewed, and findings were sorted into three overarching types of outputs: economic, environmental, and social. The specific results of community gardens identified across the literature were then included within the relevant category (see Table 1). The subcategories outlined in Table 1 emerged as studies were reviewed and trends in research were identified.

Table 1: Categories of community garden outputs evaluated

Economic	Environmental	Social
Property Value Productivity of Vacant Land Produce Value Food Bill Savings	Ecosystem Services Protections and revitalization of vacant land Carbon footprint	Learning, Education, Recreation Social Cohesion Food Security Neighbourhood Safety and Crime Prevention Mental Health Physical Health

Literature synthesis: community garden impacts

Economic

Property Values

Urban public greenspaces have been shown to enhance neighbourhood aesthetics, providing attractive spaces for social interaction, increasing supervision and safety, and fostering a "sense of place" (DeFields, 2013). They have been linked to enhanced property values, neighbourhood stabilization, and fewer vacant homes (De Sousa, 2003; Heidt & Neef, 2008; Kelly & Zieper, 2016; McCabe, 2014; Voicu & Been, 2008). The extent of property value impacts, however, remains contested, with impacts largely dependent on site characteristics and context. Table 2 summarizes several studies exploring the impact of various forms of greenspace on property values.

Eight studies assessed the association between community gardens and property values (see table 2). In one study of community gardens in New York City, Voicu and Been (2008) estimate the difference between real estate values near community gardens and prices of comparable properties at a further distance in the same neighbourhood. Property values within 1000 feet of community gardens were found to be significantly and positively affected relative to those further away, with impacts growing over time. Within five years of their establishment, community gardens affected property values by as much as 9.4% (Voicu & Been, 2008). A 2004 study from Michigan found proximity to high quality outdoor spaces positively influenced surrounding housing values, but this was highly dependent on the type of landscape (DeFields, 2013). The presence of large trees or a healthy forest correlated to increased housing values, whereas manicured landscapes and open fields did not (DeFields, 2013) A 2016 study of Kitchener-Waterloo, Ontario found that open space (including parks and sports fields) was negatively correlated with property values for single-detached, semi-detached, and duplex homes (Babin, 2016).

Few studies account for variance of impact between low and high density neighbourhoods, and many are outdated (Bolitzer & Netusil, 2000; Bremer et al., 2003; Liu, 2008, Voicu & Been, 2008). When considering the potential for community gardens to influence property values, the attractiveness of gardens as sites for more economically-advantageous

development is rarely considered. Increased property values may also have implications on the financial accessibility of real estate surrounding community gardens (Funicci et al., 2014), hindering their use as sources of fresh produce for lower-income participants and potentially contributing to patterns of neighbourhood gentrification.

Table 2: Summary of studies on community garden impact on real estate values

Authors, Location, Year	Study Notes	Applicable Results
Bremer, Jenkins and Kanter, Milwaukee, 2003		Cost premium for three-block radius of community garden estimated at $8800 in tax revenue through increased real estate values
Liu, St Louis, 2008	Compared rent prices for properties adjacent to 53 community gardens to control sites	Median rent in community garden vicinity increased by $91 USD between 1990-2000 (compared to static rent city-wide)
Heckert and Mennis, Philadelphia 2012	Evaluated vacant lot greening program's impact on property values	Property values in areas immediately surrounding greened lots increased by up to 30%
Voicu and Been, New York City, 2008	Estimated the difference between properties within 1000 feet of 636 community gardens and comparable properties at a further distance	Within five years of community garden establishment, property values were affected by as much at 9.4% within 1000 feet of the garden. Cumulative benefits estimated at $2 million USD in property value increase per garden.
Bolitzer and Netusil, Oregon, 1990-1992	Studied the impact of open space on property values.	Properties within 1500 feet or 7.5 blocks of a 20-acre open space sold for $2670 (1990 dollars) more. Proximity to any open space was shown to boost sale prices by 1.43%.
Espey and Owasu-Edusei, Greenville South Carolina 1990-1999	Estimated impact of greenspaces on house sale prices	Small aesthetic parks correlated to 11% higher house sale prices within 600 feet
New Yorkers for Parks and Ernst & Young, New York, 2003	Evaluated impact of high-quality parks on home values	Found 8-30% increase in the value of homes located near 'well-improved parks'.
DeFields, Kitchener-Waterloo 2013	Household survey with 206 respondents on the importance of outdoor spaces on housing selection	Over 50% of respondents reported proximity to natural areas (52%) and parks and recreation (57%) as important factors in selecting a living location.

Productivity of vacant land

Vacant public land is often regarded as a fiscal and aesthetic burden (Kaufman & Bailkey, 2000). The United States is home to an estimated 425 000 brownfield sites, covering about five million acres of land and representing approximately $2 trillion USD of undervalued real estate (Kotval-K, 2016). According to San Francisco's Public Works department, each converted brownfield site saved the city approximately $4100 per year in 2012 (SPUR, 2012). Revitalization and greening of these areas has been shown to enhance neighbourhood wellbeing, individual health and safety, economic development, and environmental quality (De Sousa 2003; Kotval-K, 2016; McCabe, 2014).

Community gardens have been recognized as an effective means to transform vacant lands into productive spaces, often at low or no cost to the government (Kaufman & Bailkey, 2000; Nordahl, 2009; Ranney et al., 2010; Voicu & Been, 2008). Their cross-section of social, economic, and environmental returns makes them an inexpensive way to tap into the potential of these spaces (Veenhuizen & Danso, 2007). Municipal governments may avoid substantial costs where vacant lots are converted to community gardens and their maintenance work absorbed by community gardeners, however, further research is required to evaluate when, how, and to what extent this is the case.

Produce value

The value of garden harvests and food budget savings are the most readily quantifiable outcomes of community gardens. However, research on their production is limited given the heterogeneity of garden and gardener characteristics under study, as well as the diverse methods by which researchers have quantified yield and harvest value. It follows that studies present a wide spectrum of production possibilities for community gardens' production potential. Five studies are summarized in Table 3, reflecting the variance in yields and lack of recent studies that capture equivalent produce value when accounting for input costs.

The average community garden plot in Duchemin and colleagues' (2008) Montreal study produced enough to meet the average adult's vegetable needs for the year, but this assumes production extends continuously and consistently throughout the entire year, which is unrealistic for the climate context and associated growing season (Duchemin et al., 2008).

Community gardens can yield significant volumes of fresh food, even if exact values are difficult to obtain (Gittleman et al., 2012). In one study from Guelph, Ontario, the average yield for 50 community gardeners was 1.43 kg per square meter (Codyre et al., 2012), or roughly 20.4 servings of fresh produce per square meter over the growing season. The authors estimate 197 000 kg of mixed vegetables were produced by Guelph gardeners using approximately 13.76 ha of land. This volume of fresh produce would be sufficient to meet the vegetable demand of nearly 2900 people, or 2% of Guelph's population. If 10% (as opposed to the current 0.5%) of Guelph's potential yard space was used at the average productivity rate, the authors conclude that Guelph could produce 3.86 million kg of produce annually; enough to feed 56 000 people or 46% of the city's population for a year.

Table 3: Summary of studies quantifying garden yield

Authors, Location, Year	Yield	Produce Value

Duchemin et al., Montreal 2008	35.2 lbs per gardeners per season	
Algert et al., San Jose 2014	0.75 lbs/sq. ft, 292.18 pounds per season	
National Gardening Association, United States 2009	0.5 lb./sq. ft, 300 lbs per season (600 sq. ft plot)	$600, $530 after input costs ($1/sq. ft, $0.88 after inputs)
Codyre et al., Guelph 2012	0.29 lbs/sq. ft, 4.14 lbs/sq. ft	$3.16-$5.56USD per kilogram (depending on the grocery store)
Gittleman et al., New York 2010-2011	1.2 lbs/sq. ft 2010, 0.33 lbs/sq. ft	$3/sq. ft 2010 USD, $1.15/sq. ft

Food bill savings

Building on research quantifying community garden production are studies that explore a commonly-cited benefit for participants: reduced food budget costs (Bellows et al., 2004; Carney et al., 2012; Corrigan, 2011; Gregory et al., 2016; McCormack et al., 2010; Veenhuizen & Danso, 2007). Participants in one New York study reported substantial cost savings, and 77% harvested enough to meet at least a third of their household produce needs (Gregory et al., 2016). In a study from rural Oregon, concerns of household food security dropped from 31% to 3% among a sample of migrant seasonal farmworker families following participation at community gardens (Carney et al, 2012).

The limited research in this area identifies a wide spectrum of potential food budget impacts, affected by factors such as garden input costs, yield, and the types of crops grown (Algert et al., 2014; Armstrong, 2000). Food bill savings are also dependent on methods and efficiency of production, where only a small proportion of the 50 gardeners surveyed in Guelph could produce at comparable prices to store-bought equivalents, and most were paying an average premium of 39% for their home-grown produce (excluding the cost of their labour) (Codyre et al., 2012). Studies typically evaluate impacts on food budgets by engaging gardeners in qualitative evaluations (e.g., Moskow's 1999 analysis of household food cost impacts through participant interviews) or quantitative analyses (e.g., Codyre and colleagues' 2012 study where garden yield and input costs were compared with the average costs of equivalent foods at grocery stores).

Site-specific studies are required to test whether food budget savings apply to particular contexts. Few studies express food budget savings in transferrable terms (e.g., as a value per square foot) making it difficult to apply findings to other locations. Even where savings per unit of area are provided, studies are further limited by context specificity as they only represent the productivity average of one particular set of garden conditions. Further, studies often assess the net value of community garden produce using inconsistent references for food prices (i.e., one may use a unit cost from a high-end supermarket in New York while another uses unit costs from farmer's markets in Vancouver) and without accounting for the value of labour inputs.

Environmental

UA may be a more environmentally sustainable form of production due to its shortened travel distance between producer and consumer, minimal packaging and processing, and use of waste or rainwater (Lovell, 2010). Research on the connection between community gardens and environmental outputs or valuation is limited. Indeed, UA's potential as a more sustainable food system compared to conventional agriculture is highly dependent on context and the form of UA employed (Calvet-Mir et al., 2011; Goldstein et al., 2016). For example, a study on urban versus conventional agriculture identified four types of UA based on material/energy characteristics and environmental performance and measured each form of UA's environmental impacts against traditional agricultural regimes (Goldstein et al., 2016). This study found that although some of the UA systems performed well when compared to conventional systems, results varied significantly based on the material and energy resources used and the environmental context (e.g., climate).

Community garden ecosystem services

A range of ecosystem services—defined as the benefits people gain from natural systems (WHO, n.d.)—are associated with UA, but little research has been done in this area. One study on allotment gardens in Poznan, Poland and Manchester, United Kingdom tested for 26 ecosystem services, including food provision, flood protection, water purification, and pollination, and found that the total value of ecosystem services for allotment gardens in both cities exceeded those of park areas (Speak et al., 2015). Similarly, a Spanish study engaged home gardeners to evaluate perceived value of ecosystem services (Calvet-Mir et al., 2011), identifying nineteen ecosystem services across four categories: regulating (including disturbance buffering, soil formation and fertility, pollination and enhanced crop production); habitat/support for wild plants and animals, and maintenance of genetic diversity; production (e.g., food, raw materials, and medicinal and ornamental resources); and cultural (e.g., aesthetics, social relationships, maintenance of traditional ecological knowledge).

Several of these ecosystem service outputs are not well documented across the literature; community gardens have been argued to improve air quality (Nordahl, 2009; Toronto Food Policy Council, 2012), stormwater management (Nordahl, 2009; Toronto Food Policy Council 2012), urban heat islanding or temperature regulation (Clarke & Jenerette, 2015; Lin et al, 2015; Nordahl, 2009,), and biodiversity or habitat provision (Calvet-Mir et al., 2011; Clarke & Jenerette, 2015; Lin et al., 2015; Toronto Food Policy Council, 2012), but often with limited substantiation.

Despite the challenge of quantifying environmental outcomes of gardens, efforts to tackle the monetary valuation of ecosystem services—such as the economics of ecosystems and biodiversity—offer promising avenues to capture community gardens' environmental services.

Protection and revitalization of vacant land

Community gardens are often associated with revitalization of urban lands through neighbourhood beautification and restoration, transformation and care for previously un-maintained landscapes, and urban greening (Calvet-Mir et al., 2011; Kelly & Zieper, 2016; Miccoli et al., 2014; Moskow, 1999; Nordahl, 2009; Toronto Food Policy Council, 2012; Veenhuizen & Danso, 2007; Zeeuw & Drechsel, 2015). Particularly in urban settings, which generally are dominated by low biodiversity landscapes, UA has great potential to enhance species and landscape diversity (Lin et al., 2015). Whereas this output is explored by several studies, no research quantifying the value of this revitalization of urban spaces was found.

Carbon footprint

One of the foremost assumptions about UA versus conventional agriculture is reduced greenhouse gas emissions from shortened food value chains (Miccoli et al., 2014), however research on UA's environmental footprint is mixed. For example, four studies have examined the carbon sequestration capacity of urban greenspaces and agriculture using lifecycle analyses. These assessments attempt to compare the full lifecycle impact of UA versus conventional agriculture. Three of the four lifecycle analysis studies found that at least some aspects of UA could produce emissions reductions relative to conventional methods, but these reductions were context-specific (Benis & Ferrão, 2017; Cleveland et al., 2017; Goldstein et al., 2016), while one study found no significant changes in soil carbon content in a vegetable plot across the three study years (Whittinghill et al, 2014).

In sum, the potential contribution of community gardens to the health and resilience of urban ecosystems may be significant but has been insufficiently researched. As increased research in environmental economics makes estimation of these outputs more accessible, they can be incorporated into future ROI assessments to better capture their monetary value.

Social

Many have argued that community gardens are associated with an array of potential benefits for individual participants, their households and broader communities, such as enhanced community self-sufficiency and resilience, improved food security and mental health, and increased social cohesion (Armstrong, 2000; Bellows et al., 2004; Brown & Jameton, 2000; Hou, 2009; Rich, 2012; Van den Berg et al., 2010; Vitiello & Nairn, 2009; Miedema et al., 2013).

Such outcomes, however, are extremely challenging to quantify. For example, community engagement may be quantified based on the proportion of residents involved in various local initiatives before and after the garden's establishment. However, the subsequent monetary valuation of this enhanced engagement is not straightforward. The areas of greatest opportunity to quantify potential impacts in this category include: monetary valuation of educational outcomes; any reductions in community law enforcement costs due to increased

neighbourhood cohesion and safety; any reductions in dependence on mental health services due to impacts of improved mood, social connectedness, and improved food security; and any reductions in public health service costs due to improvements in physical health. Many of these remain contested or insufficiently studied community garden outcomes, as we discuss in the subcategories below.

Community health

Community gardens have been described as "a catalyst for community participation and community revitalization" (Hou 2009, p.22), serving as robust alternatives to vacant plots which are often associated with undesirable impacts including heightened criminal activity, dumping, and safety hazards (Schukoske, 2000). They are purported to support neighbourhood self-sufficiency, cross-cultural interactions, and social ties (Alaimo et al., 2016; Dieleman, 2016).

Learning, education and recreation

Community gardens are recognized as sites of informal learning opportunities (Alaimo et al., 2016; Drake & Lawson, 2015; Hou, 2009; Ranney et al., 2010; Schmelzkopf, 1995' Veenhuizen & Danso, 2007), including agricultural training programs (Rich, 2012), environmental education, and scientific research (Calvet-Mir et al., 2011). Participants have reported increased knowledge of food production, greater awareness of environmental issues, improved dietary behaviours and preference towards fruits and vegetables, and deeper respect for farmers (Miedema et al., 2013).

Community gardens have also been recognized as a form of recreation (Calvet-Mir et al., 2011; Veenhuizen & Danso, 2007) and for their impact on youth development. Research on neighbourhood community garden youth programs in Flint, Michigan found they provided a constructive activity where participants could contribute to their community and develop several important skillsets (social, nutritional, agricultural) (Ober Allen et al., 2008).

Social cohesion

Community gardens are often regarded as fertile grounds for social interaction and community building (Calvet-Mir et al., 2011; Duchemin et al., 2008; Ober Allen et al., 2008; Veenhuizen & Danso, 2007), particularly given their location in public spaces. They have been described as 'social anchors' for a community (Rich, 2012), facilitating social interaction across age, cultural, and income groups (Miedema et al., 2013; Ranney et al., 2010; Veenhuizen & Danso, 2007). Studies across Australia, North America, and the UK suggest that food production is linked to community development, and that "gardens can contribute to social capital through civic engagement" (Drake & Lawson, 2015, p.243).

By introducing what Hou describes as a "community commons" (Hou, 2009 p. 22) where neighbours can interact, community gardens may contribute to placemaking, neighbourhood

resilience, autonomy, and pride (Alaimo et al., 2016; Armstrong, 2000; Calvet-Mir et al., 2011; Hanna & Oh, 2000; Hou, 2009; Litt et al., 2015; Ober Allen et al., 2008; Ranney et al., 2010; Rich, 2012; Vitiello & Nairn, 2009). A study by Kuo and colleagues (1998) found that higher levels of vegetation in a neighbourhood common space are associated with stronger social ties, and several studies indicate that robust social ties form a "social unit more capable of forming local organizations, defending against crime, and mobilizing for political purpose" (Kuo et al., 1998, p.824). In other words, connected neighbourhoods with strong relationships of mutual trust yield increased local capacity and more engaged, resilient communities.

Revitalization of vacant land has been shown by several studies to improve community wellbeing and public health, particularly when it is transitioned into a site of "purpose, people, and active use" (Garvin et al., 2012, p. 422). As one form of brownfield greening that fulfills all three of these attributes, a community garden has the potential to act as "a catalyst for community participation and…revitalization" (Hou, 2009, p.22).

Enhanced social connectedness can improve neighbourhood support networks and build trust, strengthening the social fabric of a community (Alaimo et al., 2016). Research by the National Collaborating Centre for Healthy Public Policy found that a sense of community belonging was positively associated with individual health (Watson & McDonald, 2016). A study by Waterloo Region Public Health found that 81.8% of individuals with a strong sense of community belonging were satisfied with their mental wellness, compared to 58.1% of those with a low sense of belonging (Watson & McDonald, 2016).

While qualitative research validating community gardens' impact on community connectedness and resilience is strong, this outcome remains extremely challenging to estimate in economic terms.

Food security

The World Food Summit of 1996 defined food security as an interplay between four dimensions: food access, availability, utilization, and stability. Together, these dimensions form a state of food security where "all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2006, p.1). Household food insecurity is defined as "inadequate or insecure access to food because of financial constraints" (Tarasuk et al., 2016, p.2).

In Ontario, an estimated 12.5% (or 1.7 million) of households were food insecure in 2012 (Ontario Food and Nutrition Strategy Group, 2017). Food insecurity has been associated with reduced physical and mental health, increased risk of chronic disease, hindered school success and childhood development, and heightened potential to become higher-cost healthcare clients (Birmingham, 2008; Ontario Food and Nutrition Strategy Group, 2017; Tarasuk et al., 2015). Household food insecurity is a robust predictor of health care utilization and costs among adults in Ontario, even after controlling for several social determinants of health (Tarasuk et al., 2015).

The studies summarized in Table 4 show that UA may enhance food security as a relatively low-barrier option to increasing household food supply (Avila & Veenhuizen, 2002; Veenhuizen & Danso, 2007) and by improving access to fresh food (Alaimo et al., 2008; Armstrong, 2000; Rich, 2012; Wang et al., 2014). The five studies captured in Table 4 describe qualitative results from participants who experienced improved food security due to involvement in community gardens, and significant quantitative results on the production potential of gardening compared to average adult fruit and vegetable needs. For example, in a New York study of 61 urban gardens, 55% of gardeners reported sufficient harvest to meet two-thirds of their vegetable consumption (Gregory et al., 2016).

Table 5: Summary of studies on community garden impact on food security

Authors, Location, Year	Study Notes	Applicable Results
Gregory, Leslie & Drinkwater, New York City 2015	Engaged 61 food-producing gardens across 2011-2012. 40% of gardens were less than 500 meters squared, about 70% under 1000 meters squared.	55% of gardeners reported sufficient harvest to meet 2/3 of their vegetable consumption, 22% produced between 1/3-2/3 of their produce needs.
Vitiello and Nairn, Philadelphia 2008	Summary of Philadelphia community garden production and distribution, involving site surveys, harvest-weighing and gardener interviews.	Nearly 12 000 pounds of fresh vegetables distributed to food banks through gardener donations to City Harvest 2008
Duchemin Legault & Wegmuller, Montreal 2008	Engaged over 560 participants in a study of Montreal's urban agriculture.	Average garden yield was about 16 kilograms per gardener over the growing season (May to October), enough to meet average produce needs of one adult if production was to remain constant throughout year
Carney et al, Oregon 2011	Examined community gardens' impacts on 42 seasonal migrant worker families in a rural community, 2009	Food security concerns diminished following participation in community gardens (from 31% to 3%)
Kobayashi, Tyson & Abi-Nader, USA, 2010	Examined impact of Community Food Projects Competitive Grant Program (CFPCGP) which supports community food projects across the United States (30% of projects community gardens).	Between 2005 and 2009, almost 19 million pounds of local produce distributed through 307 CFPCGP projects, with impacts concentrated in low-income communities across in 39 states

Research on squatter and community gardens in Philadelphia found that the 600 surveyed sites were concentrated in lower-income neighbourhoods, with the potential to support food security among lower-income residents (Vitiello & Nairn, 2009). Insofar as community gardens are regarded as enablers of food security in lower-income neighbourhoods, their spatial distribution and demographics are highly variable and depend on local context. For example, in Portland and

Vancouver, residential gardeners were predominantly white, female, older, more highly educated, and wealthier compared to population averages for the cities (Mclintock et al., 2013). Community gardens are not always located in the lowest income areas and are sometimes not used by low-income residents even when gardens are located in these areas (Smith et al., 2013). In a Toronto survey of community food programming projects (community gardens, food box programs, and community kitchens), low participation rates were found among low-income residents and these programs were found to be ineffective in supporting their needs (Loopstra & Tarasuk, 2013).

On the other hand, several studies suggest that community gardens have promising potential as a food security intervention and that many are effectively used in higher-needs neighbourhoods (Garrett, 2015; Voicu & Been, 2008). In New York, census tracts with gardens had significantly lower mean income ($29 649 USD) compared to areas without gardens ($45 593 USD), higher unemployment and poverty rates, and lower education and ownership rates (Voicu & Been, 2008). A National Gardening Association survey found that although a significant number of higher income-earners participated in food gardens, the largest household income group of community gardeners earned between $35-$49 999 USD (24% of respondents), with 21% earning under $35 000 (National Gardening Association, 2009). Continued research on food security outcomes associated with UA is needed to validate this relationship (Mah et al., 2014).

Crime prevention and neighbourhood safety

Research is currently insufficient to draw robust conclusions about the association between crime and community gardens, however studies indicate that greening interventions or increased healthy vegetation correlate to enhanced sense of safety and declines in robberies, burglaries, property crimes, vandalism, theft, and violent crime (Bogar & Beyer, 2016; Garvin 2012). Efforts to reduce or prevent criminal behavior can have substantial ripple effects on community wellbeing and lowered policing costs. Beyond immediate crime response expenses, the total costs of crime and victimization were estimated at $99.6 billion in 2008 (Zhang, 2011), or about $114 billion in 2017 dollars. These costs include expenses associated with courts, prosecution, legal aid, correction, victim support, and compensation (Zhang, 2011).

Community gardens have been found to positively impact neighbourhood security (Armstrong, 2000; Moskow, 1999; Ladner, 2011; Ober Allen et al., 2008), providing safe spaces which are invested in and valued by the community. Research generally evaluates impacts of community gardens on neighbourhood safety based on differences in incidents of crime before and after a garden's establishment, or through a comparison of crime rates in neighbourhoods with community gardens versus control sites.

Table 5 distills the findings of five studies evaluating the impacts of community gardens and vacant lot greening on crime. While the findings are inconsistent across the urban environments studied and are noted to have been limited by sample size, timespan, and difficulty isolating

community gardens as the causal variable, each of the studies did identify positive results from increased greenspace and/or the introduction of community gardens. In one study of three community gardens in Kitchener, Ontario, respondents reported that gardens foster a sense of neighbourhood security by increasing resident interaction across cultural, age, and socioeconomic divides, transforming previously disorderly sites and increasing informal surveillance or visibility at the site (Herod, 2012).

A systematic review of the relationship between greenspace, violence, and crime found that 19 studies reported positive impacts of greenspace on neighbourhood safety, and nine showed a negative relationship (Bogar & Beyer, 2016). This variance is believed to result from differences in neighbourhood socioeconomic characteristics prior to greening, the type of greenspace, and type of crime (Bogar & Beyer, 2016' Garvin, 2012; Heckert & Mennis, 2012).

Table 6: Impact of community gardens on crime

	Description	Impact
McKay, Kitchener, Ontario, 1994	Assessed the impact of Victoria Hills community garden on police incidents	Incidents dropped by 30% the summer following the community garden's establishment and nearly 56% by the third summer.
Garvin, Philadelphia, Pennsylvania, 2011	Randomized testing of vacant lot greening (cleaning lots, planting grass/trees, fencing perimeter) on reported crime, safety, and disorder. Research engaged 29 participants, 2 intervention sites and 2 control sites	Total crimes at intervention sites increased slightly, however a net reduction in perception of disorder was found among residents by intervention sites compared to control sites. The sample size and timespan of this study posed significant limitations to findings.
Gorham, Waliczek, Snelgrove & Zajicek, Houston, Texas, 2009	Evaluated impacts of 11 community gardens on reported property crimes when compared to control sites.	Interview participants reported reductions in illegal activities such as dumping or drug activity, increased property values, neighbourhood redevelopment and increased resilience against crime. Only 1 of 6 gardens evaluated in-depth showed statistically-significant change in property crime rates of the garden site versus control site. The remaining 5 sites showed mixed results. Community gardening is concluded to be a tool for community revitalization, but not a predictor for neighbourhood property crime.
Kondo, Hohl, Han & Branasl Youngstown Ohio, 2010-2011	Compare neighbourhood crime rates between vacant lots and greened lots (remediated through a city-led brownfield revitalization program). 47 out of the 77 lots included in the program were converted into community gardens, urban farms or orchards.	Community-led revitalization projects showed the greatest reductions in felony assaults and burglaries. The greened lot program led to statistically significant decreases in burglaries, robberies and felony assaults.
Snelgrove, Michael, Waliczek & Zajicek, Austin, Texas, 2004	Evaluate relationship between crime and greenspace	Findings indicate that higher levels of greenspace support reduced criminal activity and safer communities

Whereas the findings of these studies and assertions present mixed evidence of correlation between the presence of community gardens and crime prevention, they collectively

present evidence that gardens can support residents' perceptions of neighbourhood safety. The studies are limited in that they employ inconsistent references against which garden impacts can be measured (i.e., crime reporting rates, incident rates, comparisons of criminal activity pre-and-post garden establishment or comparison to control sites), and many call for continued research to explore this relationship. Studies on comparative crime rates and community safety between garden and control sites must delve more deeply than basic measures like percentage changes in crime reporting, since these measures can have several root causes and misrepresent the circumstances (e.g., increased reporting of crime by residents may be indicative of increased investment in the community and informal surveillance, not necessarily a rise in crime incidents).

Individual health

Mental health

Mental and physical health are widely understood as deeply interconnected dimensions of individual well-being (Watson & McDonald, 2016) and support for mental health is regarded as essential to a community's overall health and safety. The WHO 2014 Mental Health estimated that mental illness-related healthcare in Canada cost roughly $42.3 billion in 2011 (Smetanin et al., 2012). Estimated costs of mental illness rarely capture long-term, persistent costs or indirect expenses. These indirect and long-term impacts are difficult to quantify, but they are substantial. For example, Canada's workplace productivity loss resulting from mental illness was an estimated $6.4 billion in 2011 (Watson & MacDonald, 2016).

Natural spaces promote individual wellness (Adevi & Lieberg, 2001; Beyer et al., 2014; Van den berg et al., 2010), and community gardens have been tied to significant improvements in participant mental health (Carney et al., 2012; Clatworthy et al., 2013; Husqvarna Group, 2013; Ladner, 2011). Research in this area typically measures mental health impacts based on differences in symptoms of mental health (e.g., stress, anxiety, depression) between gardeners and non-gardeners, or more broadly between residents in neighbourhoods with higher levels of greenspace than others.

Gardeners report lower levels of depression and anxiety and improved mood, self-esteem, social skills, sleep, and physical health relative to non-gardeners (Clatworthy et al., 2013; Mah et al., 2014). Gardening may act as a powerful tool which contributes to feelings of vitality and wellbeing in individuals struggling with mental illness (Adevi & Lieberg, 2011). However, research presents varied and insufficient data on mental health impacts over the long-term (Clatworthy et al., 2013), rarely considering how these improvements impact mental health service use and healthcare costs. Such analysis is necessary to capture monetary impacts of community garden-related mental health improvements.

Physical health

Improvements in nutrition (Alaimo et al., 2008; Bellows et al., 2004; Wang et al., 2014; Vitiello & Nairn, 2009) and physical activity are often purported to be associated with community garden participation, however, these outcomes continue to be debated and require further research to validate.

The presence of parks and open spaces in a community have been found to positively correlate to increased desire of residents to be physically active, particularly for seniors (Alaimo, 2016; Power Up for Health Foundation, 2016). Conversely, a 2003 literature review on the impact of UA interventions on nutrition found mixed results among study participants and insufficient evidence to substantiate the connection (Berti et al., 2004).

Studies in this area are limited by small sample sizes, lack of control groups, failure to account for self-selection or sample bias, and inconsistent indicators or measurements for analysis. Results on physical health impacts are inconsistent, and sometimes rest on un-validated assumptions of community garden outcomes (Mah et al., 2014).

Conclusions and directions for future research

The production of food in cities is increasingly being explored as a dimension of sustainable urban living. The outputs of UA are rarely quantified, however, which may hinder recognition of their value among decision makers. In response to this gap, this paper has reviewed the literature on community gardens' social, environmental, and economic impacts with an eye towards data needs to complete an ROI analysis.

The contextual diversity of community gardens makes site-specific data extremely important and hinders cross-application of studies from other contexts, however, local-level data and controlled studies remain sparse. Research areas requiring further site-specific or controlled studies include the impacts of community gardens on food bill savings and produce value, gardens' ecological impacts such as carbon sequestration and stormwater management, as well as food security outcomes.

Future research should build on several shortcomings in current studies. Impacts of community gardens on property value must account for other factors affecting real estate markets, potential unintended outcomes such as gentrification, and variation of impacts due to neighbourhood density. Assessments of the relationship between neighbourhood safety and community gardens require consistent measurement of impact (e.g., crime reporting rates) and should investigate how community gardens and crime are associated. Physical health impact studies require larger sample sizes, control groups, and consistent indicators of assessment. Mental health studies must capture longer-term impacts of community gardens on mental wellbeing and consider the direct effect of participation on mental health service use.

Research is also inadequate in its consideration of potential unintended outcomes of community gardens and their implications for social equity. Gardens' accessibility across

variables such as age, background, and economic status must be explored to better understand how impacts are distributed across a community.

In conclusion, data and research on community gardens is currently inadequate to generate accurate ROI analyses. However, there is significant potential for such quantitative measurement of their outcomes to reflect their value in policy making. Further research is needed to enable production of ROI assessments of these spaces to guide investment decisions around the place of community gardens in community wellbeing and sustainable urban food systems.

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