**Locavoracious: What are the impacts and feasibility of satisfying food demand with local production?**

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Abstract:
Growing concern over global food security and environmental sustainability has popularized the local food movement within many industrialized countries. While context-specific, the impacts and feasibility of localizing diverse food systems are subject to similar parameters and analytical approaches, which have not evaluated holistically. I conduct a systematic review of peer-reviewed literature assessing the impacts and feasibility of local food systems. I demonstrate that knowledge of environmental impacts is well-developed in comparison to economic and social elements, while feasibility analysis over-simplifies networks of food production and consumption as geographical alignment of supply and demand. As policymakers strive to improve food security at multiple scales, there is inadequate consideration of external market forces and infrastructure that are crucial in determining local food distribution and availability.

Key words: Local, Food systems, Systematic review, Impacts and Feasibility.

## Introduction

In many industrialized countries, conventional agriculture consists of large-scale, monoculture, highly mechanized, as well as pesticide- and fertilizer-intensive production. Alternatives to these methods, including small-scale, family-operated, organic, diversified, and direct-to-consumer trade, are receiving positive attention in the media (Cahill et al., 2010). This is because there is growing recognition that conventional food systems threaten environmental sustainability and global food security (Godfray et al., 2010). Strengthening local networks of food production, distribution, and consumption is purported as one effective way to promote human health, ecological sustainability, as well as social and economic justice (Horrigan et al., 2002; Anderson, 2008). The phrase 'food miles' has perpetuated the presumption that local is preferable to distantly-sourced food, mainly because of reduced greenhouse gas emissions during transport (Edwards-Jones, 2010).

Global environmental and social change provide essential context for the local food systems debate (Ericksen, 2008). Agriculture itself may be an important driver of climate change, as it currently contributes 14% of anthropogenic greenhouse gas emissions, while climate change in turn impacts crops yields through increased variability in temperature and precipitation (Grunberg et al., 2010). There are additional forces that alter food prices and food security (Peters et al., 2009b), such as unstable petroleum supplies affecting costs of food transport (Grunberg et al., 2010). Around the world, conventional agricultural systems can also create social unrest through mistreatment of migrant laborers in fields and food processing facilities, high food prices, limited food access, inequitable allocation of revenue, as well as ‘land-grabs’ initiated by governments or agribusinesses in developing regions (MacKenzie, 2008; Cassady et al., 2007; Mitchell, 2003). It has been argued that eating globally obscures these negative impacts of food production, while eating locally can catalyze positive local change (Kloppenburg and Lezberg, 1996). The benefits of bolstering local food production thus seem intuitive in improving a community’s resilience to shocks in global food markets.

However, current discourse on the benefits of local food systems is contentious. First, food products considered local and/or alternative are not necessarily independent of conventional food systems. Local food producers depend on a mixture of local, national, and international suppliers and distributors, and it is the geography of these linkages between businesses that determines whether or not a product is local (Maye and Bery, 2006). Born and Purcell (2006) point out that desirable environmental and health outcomes are not necessarily derived from local production. They argue that the local movement is conflated with other elements of sustainable agriculture and misguidedly positions local scale as an end unto itself, rather than a means for achieving certain outcomes (ibid). Furthermore, localizing food systems do not necessarily align with desirable social or political outcomes (Berrang-Ford et al., 2011). Other trade-offs to consider include nutrient deterioration and physical damage that may occur during transport of produce. However, the rapidity of current transportation networks allows for the taste and nutritional quality of imported fresh food to be equal or superior to foods that are harvested locally and stored (Edwards-Jones, 2010; Edwards-Jones et al., 2008). Furthermore, attempts to increase food self sufficiency in certain areas may necessitate growing on land that is less suitable for cultivation, increasing environmental impacts and greenhouse gas emissions while decreasing yields, and therefore, farmers’ incomes (Edwards-Jones, 2010).

Because the environmental, socio-political, and economic factors that impact and are impacted by food systems are so complex, they are very difficult to evaluate. However, several analytical tools have undergone substantial development. For example, community food assessments are used in the United States for evaluating food security and identifying ways to enhance it within a particular locale (Pothukuchi, 2004). However, these assessments are limited to government and NGO documents and are not available in the peer-reviewed literature (ibid). Life cycle assessment is another tool, successfully employed in a literature review to compare local and non-local food systems with respect to environmental impact (Edwards-Jones et al., 2008). Foodshed[1] analysis has emerged as a way to assess the origins of food consumed in different areas, and then seek out alternative sources to minimize the food system’s environmental impact and vulnerability to shocks in external production or distribution systems (Peters et al., 2009b). Foodshed analysis offers a place-based approach to understanding

[1] A foodshed is any area producing food that is processed, purchased, and consumed by a geographically endogenous population (Peters, Bills et al. 2009b). A foodshed is thus the geographical unit that contains a food system. Many food commodities are currently exchanged within a global foodshed. Efforts to localize foodsheds decrease the distance of linkages (from producer, distributor, to consumer) that comprise food systems.

local food (Duram and Oberholtzer, 2010), and has implications for informing policy that aims to bolster food security and reduce environmental burden within a foodshed.

Our knowledge of the impacts and feasibility of localizing food systems in industrialized countries is certainly rife with mixed messages. There is need to research the impacts of localization inductively from empirical evidence, rather than deductively from prejudice regarding whether local food systems are inherently good or bad (Sonnino, 2010). It is also important to assess whether movement toward local food systems is feasible for meeting the food needs of populations (ibid). There is currently no effort in the peer-reviewed literature to consolidate and compare findings of the impacts and feasibility of localizing food systems in different settings. In light of these research gaps, I systematically review two central questions that must be understood before pursuing policies that either promote or disregard local food systems. First, is localization *desireable*? That is, what are the economic, environmental, and social impacts of localizing food systems? Second, pending positive answers to the first question, is localization *feasible*? Here, I take feasibility to indicate that local foods can meet the dietary needs and preferences of a local population—which will vary with food production, distribution/processing, and retail environments.

## Methods

To address my research questions, I used the methodology 'systematic review,' which is a literature review of research articles that seeks to answer a particular research question with standardized methods (Engberg, 2008). Because systematic reviews make their methods and literature search criteria explicit, they are in theory reproducible and are thus considered a scientifically rigorous tool for evaluating evidence (Kaczorowski, 2009). While they originated in the biomedical field, systematic reviews are increasingly applied in the social sciences to evaluate the efficacy of public health interventions functioning in complex and open systems (Petticrew and Roberts, 2006). Moreover, they are also being used to establish the state of knowledge in a given area in a standardized and rigorous manner that can be tracked over time, particularly in fields such as climate change where the body of research is expanding rapidly and needs for knowledge synthesis are high (Berrang-Ford et al., 2011; Ford et al., 2011a; Ford et al., 2011b). I ultimately chose the systematic review methodology because this latter application aligns best with the intent of my own research questions: to "consolidate and compare" existing evidence in the diverse and growing field of food systems. The method is rigorous but adaptable to complexity.

I conducted a systematic search of primary studies assessing the impacts and feasibility of food system localization The literature search was structured around two central topics: local food systems impacts and feasibility. 'Impact studies' analyze how local food systems (independent of other characteristics, such as organic); affect environment, social structures, economies, and/or human health. Within the scope of this review, impact studies explore the advantages and disadvantages of local food systems, and frame how these factors should be considered when assessing whether local food systems are feasible in particular locations. 'Feasibility studies' analyze agricultural and population trends within specific regions to test the ability of food production within that area to meet food need. Table 1 provides an overview of criteria used to determine whether an article retrieved in my literature search was relevant to my research questions. I differentiated between impact studies and feasibility studies based on research aims and methods, though it became evident that most studies assessed elements of both impacts and feasibility. It is expected that feasibility studies will incorporate analysis of impacts, as the feasibility of meeting local food need largely depends on availability of natural resources, and viability of social and economic systems.

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| • English<br>• Peer-reviewed journal article<br>• Study is explicit about data sources and methods.<br>• *Impact studies:* Involves analysis of tangible outcome of foodshed localization (potential or actual).<br>• *Feasibiltiy studies:* Unit of analysis is foodshed**.** Scale of foodshed is clearly defined as a nation, region, or community. Objective is to analyze feasibility of local foodshed in meeting the nutritional needs of a population. | • Non-English<br>• Book chapter, conference proceedings, grey literature, or other.<br>• Data sources, analytical methods, or geographic scope of study is not clear.<br>• Does not focus on (relative or absolute) impacts or feasibility of local food production and consumption. |

**Table 1:** Inclusion and exclusion criteria used to select studies in systematic search

Identical keyword searches were performed in the ISI Web of Knowledge (WOK) and Agricola electronic citation databases, though Agricola did not yield any additional articles beyond those selected from WOK. The titles, and if necessary, abstracts and bodies of studies retrieved by electronic searches were scanned for adherence to inclusion criteria. In addition, I used snowballing through bibliographic and forward citation searches to retrieve additional relevant articles. See Table 2 for a breakdown of search terms and results. Search terms were kept broad to enhance the search's sensitivity in retrieving relevant articles with a diversity of key words or titles. Search sensitivity is particularly important for topics that are multidisciplinary or not well established in the peer-reviewed literature (Petticrew and Roberts, 2006). This is certainly the case for food systems research, which has evolved to transcend disciplinary boundaries.

| Search Terms | # Retrieved | # Included | Citations |
|---|---|---|---|
| Topic = (foodshed*) in WOK | 9 | 2 | (Peters et al., 2009a) |
| Topic=(health AND "food security" AND local) In WOK | 131 | 1 | (Ostry and Morrison, 2010) |
| Topic=("food system*" AND local AND health) In WOK | 56 | 2 | (Desjardins et al., 2010, Cross et al., 2009) |
| Title=("local food" OR "Food miles") in WOK | 153 | 5 | (Sim et al., 2007, Blanke and Burdick, 2005, Weber and Matthews, 2008, Pretty et al., 2005, Ballingall and Winchester, 2010) |
| Snowballing | N/A | 5 | (Vanbers and Robinson, 1993, Mumford, 1956, Peters et al., 2007, Cowell and Parkinson, 2003, Risku-Norja et al., 2008) |
| *Total* | | *15* | *7 'impact' studies*<br>*8 'feasibility' studies* |

Table 2: Search terms and results

Quality appraisal of selected articles is an important stage in systematic review, in order to highlight where the strongest evidence lies (Petticrew and Roberts, 2006). Due to the context-contingent nature of food system localization and the diversity of regions and approaches included in primary studies, my inclusion/exclusion criteria do not contain methodological standards. I adapted the critical appraisal guidelines developed by Heller et al. (2008) and Fowkes and Fulton (1991) to emphasize external validity, or generalizability, as well as data sources and sampling methods.

I developed a questionnaire (see appendix) to extract evidence from selected studies in a systematic way, with special focus on each study's conceptual frameworks to facilitate understanding of impacts and/or feasibility of local food systems. I used thematic coding to collate evidence extracted from these questionnaires. This involved grouping similar ideas together from each element of the questionnaire, and distilling these into general concepts and key themes (Boyatzi, 1998), qualified by the particular contexts of each study.

## Results

### Impact studies

The search for impact studies yielded seven results (Table 1 in Appendix); one addressed economic impacts (Pretty et al., 2005), four addressed environmental impacts (Weber and Matthews, 2008; Blanke and Burdick, 2005; Mumford, 1956), while two addressed social impacts on farmers (Cross et al., 2009; Ballingall and Winchester, 2010) Table 1 in the appendix summarizes the focus, metrics and analytical approaches employed in each article.

*Economic impacts*

Pretty et al. (2005) quantify the 'true cost' of the average weekly food basket in the UK, including costs of production, transport to retail outlets and consumer homes, and waste disposal. The cost includes environmental and social externalities like air and water pollution, soil erosion, biodiversity loss, and adverse effects to human health from pesticides and microorganisms, as calculated by a previous study (Nash and Salmon, 1999). These costs are born by the government (and thereby tax-payers), and manifest themselves through environmental monitoring and remediation, health care, as well as road repair and maintenance (Pretty et al., 2005). However, the authors only assess 12 food commodities and do not consider positive externalities arising from current agricultural systems, only negative ones, and acknowledge that this may bias their analysis against conventional food systems. The study predicts that if all products within the UK food basket were sourced within 20 km of retail outlets, avoided costs would be approximately 2119 million pounds per year. Meanwhile, in a national food system that emphasizes rail transport, savings are reduced to 1506 million pounds per year (ibid: Table 6). In contrast, if all farms in the UK were organic, externalities would only be reduced by 1129 million pounds per year, a bit over half of savings from localizing food systems. This indicates that domestic transport of food incurs greater impacts on costs than the use of fertilizers and pesticides in cultivation. Meanwhile, reducing transport distances yields greater savings than converting transport mode from truck to rail. However, because this analysis is based on comparison of complete localization and a complete shift to organic cultivation, it is difficult to understand the dose-response relationship between costs and changes in food production and transport methods.

*Environmental impacts*

Environmental concerns are most prominent in the peer-reviewed literature, and include impacts of local food systems on energy use (Mumford, 1956; Blanke and Burdick, 2005), greenhouse gas emissions (Weber and Matthews, 2008), and other variables such as biodiversity and soil erosion (Sim et al., 2007). All four of these studies use life cycle assessment (LCA) as an analytical tool to compare the environmental impacts between food products in local and non-local systems. LCA is a well-established and sophisticated approach to estimating the cumulative environmental impacts of diverse products and services through each life cycle stage (Sim et al., 2007). While transportation distance is the most obvious element of a food product's life cycle that will differ between local and non-local systems, the retrieved studies use LCA to illuminate other differences, such as food cultivation practices, storage, processing, and temperature moderation.

Across global and local scales, dominant environmental impacts of food systems include global warming, abiotic depletion, and acidification (Sim et al., 2007), as well as energy use (Blanke and Burdick, 2005), though these impacts depend on the type of food product and volume transported (Mumford, 1956). Transport mode is a particularly important determinant of environmental impact at all levels (Sim et al., 2007; Weber and Matthews, 2008; Mumford, 1956). For international transport, shipping is significantly more energy-efficient than air-freight (Sim et al., 2007), while domestic transport via rail yields less economic externalities than trucking (Pretty et al., 2005). Trucking was found to account for the majority of greenhouse gas emissions due to transport within the U.S, despite its relatively small share of ton-kilometers in domestic transport of food (Weber and Matthews, 2008).

Relative to the environmental impacts of food transportation, those of production methods may be more significant. Weber and Matthews (2008) found that transportation as a whole accounted for only 11% of greenhouse gas (GHG) emissions within the U.S, while food production accounted for 83% (ibid). Emissions due to production varied largely by food type, with meat and dairy emitting the most GHGs. In fact, shifting only 11%-19% of current consumption levels of red meat and dairy towards chicken, grains, or fruits/vegetables, would reduce GHG emissions to the same levels as if complete localization were achieved—that is, if all transport distance between farms and retail stores were eliminated (ibid). This finding of relatively small GHG emissions from transport resonates with the conclusions of Sim et al. (2007) that transport contributes less to environmental impacts of domestic food systems than other factors, such as packing and storage. With regards to cultivation practices, there was no consistent pattern when comparing the impacts of organic versus conventional cultivation within global, regional, or local foodsheds (ibid). However, the authors acknowledge this may be because farms included in the study do not constitute a representative sample. As mentioned, the findings of Pretty et al. (2005) suggest that localizing transport may have greater economic (not environmental) impacts on cost reduction than cultivation practices—specifically, transitioning to organic.

The relative impacts of local and non-local food systems on energy consumption are ambiguous, though the significant role of transport is clear. A life cycle assessment based in Germany found that local fruit juice production was less energy-efficient than importing fruit concentrate from South America (Mumford, 1956). This is because transport of international products often entails large volumes brought by ship, while transport and distribution of local juice in low volumes by truck or car uses more energy per unit weight or volume, a phenomenon the authors term ‘The Ecology of Scale’ (ibid). A comparable study based in Germany assessed the energy requirements of locally grown apples relative to imported apples over the course of each product’s life cycle (Blanke and Burdick, 2005). This included cultivation, transport, and cooling for various time intervals. They demonstrated that imported apples required 27% more energy per kilogram than apples produced domestically, with most of that extra energy stemming from transport over greater distances, in conjunction with cooling the fruit during transport (ibid). The authors attribute the contrasting findings of Schlich and Ulla to their comparison of small, inefficient, and remote juicing operations at the local scale to non-local juice made from imported concentrate out of large-scale factories (ibid).

*Social impacts*

Discussion of the social impacts of localization focuses on differing roles of agriculture and farm workers between industrialized and developing countries. These differences are important because industrialized countries are overwhelmingly the proponents of localization, discouraging consumption of food products imported from developing countries, which may depend on those exports for national income (Ford et al., 2011a). Analysis of the economic effects of a shift in preferences in the UK, France, and Germany towards local foods reveals that the greatest welfare losses occur in Sub-Saharan Africa, because the GDPs of countries such as Malawi are largely driven by exporting food and other horticultural products to Europe (Ballingall and Winchester, 2010). The research was based on an ‘iceberg’ approach to economic modeling, which assumes a linear relationship between distance of food source with the decline or ‘melting’ in consumer preference based on that distance. This suggests that the world’s poorest and most remote nations may suffer from a shift in preference for locally-produced foods among European countries, due to local food campaigns (ibid).

In addition, the status of farm workers relative to the rest of the national population is lower in industrialized countries than in developing countries, which Cross et al. (2009) demonstrated by comparing self-reported health of farm workers in two countries in Europe and two in Sub-Saharan Africa. Farmers in Kenya tended to have higher status than general populations, while farmers in the U.K, largely comprised of migrant populations, had lower status. Within Kenya, farmers on export farms had higher health status than those on non-export farms. This is because export workers are usually provided amenities like housing, secure incomes, health care, and free transport to and from work, and so their livelihoods tends to be better-supported than other rural dwellers in Kenya and Uganda. The authors suggest that support of local food systems in the U.K may perpetuate exploitation of migrant and low-income workers on local farms, while retracting support from more socially just labor systems abroad. However, a broader sample and comparison of more local- and export- oriented farms in each country are necessary to strengthen this inference.

**Feasibility studies**

Eight studies assessed the feasibility of meeting food demand with local production, all within industrialized countries (see Table 2 in appendix). These studies were explicitly or implicitly framed as foodshed analysis, in that they compared food supply and food demand within a defined geographic area. One feasibility study assessed local food production and consumption at the national level (Cowell and Parkinson, 2003) and another at national and constituent regional levels (Vanbers and Robinson, 1993). Two studies looked at state/provincial food systems (Peters et al., 2009b; Ostry and Morrison, 2010; Peters et al., 2009a; Peters et al., 2007), and three at the level of metropolitan agglomerations (Kurita et al., 2009; Desjardins et al., 2010; Risku-Norja et al., 2008) In terms of temporal scales, two Canadian studies projected current trends in agricultural production and food consumption to predict the potential for food self-reliance in the future (Vanbers and Robinson, 1993; Desjardins et al., 2010), while one study (also Canadian) was in contrast retrospective, tracking agricultural changes in British Columbia (BC) from 1986 to 2006, and the implications of these changes for food self-sufficiency and nutrition within BC (Ostry and Morrison, 2010). All other studies used cross-sectional data to determine current feasibility of localizing food systems.

In general, I found that there is tendency for foodshed analysis, employed in all eight feasibility studies, to simplify understanding of localization feasibility to matching supply with demand within an area, without considering mediating factors like trade and transportation linkages. I graphically represent the misalignment between feasibility analysis and what is known about local food systems in impact studies (see Figure 1), and explicate the misalignment further in this section.

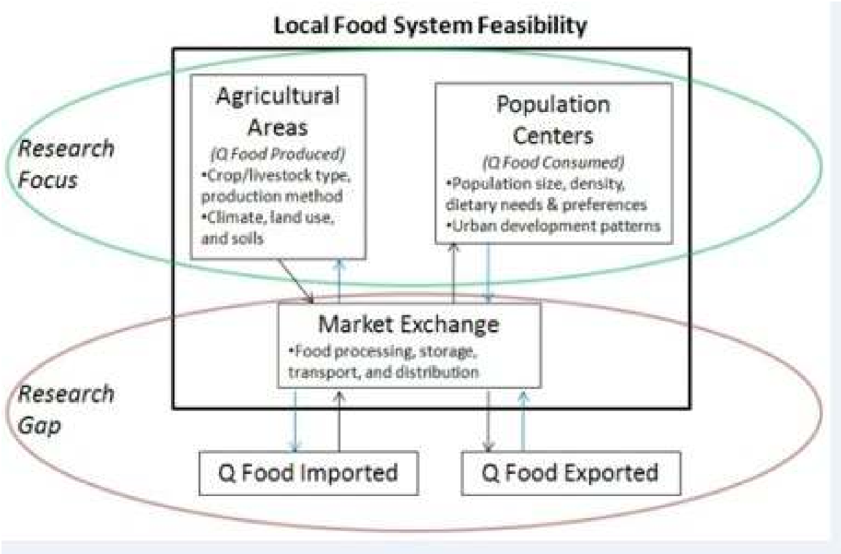


Figure 1: Local food Feasibility

Feasibility studies compare food production and food consumption within a given locality, which may be a state, region, or city. Food production was estimated through analysis of land use and soil and average yields (Peters et al., 2009a; Peters et al., 2007; Kurita et al., 2009; Risku-Norja et al., 2008; Vanbers and Robinson, 1993), or from actual food production data from previous years (Cowell and Parkinson, 2003; Desjardins et al., 2010; Ostry and Morrison, 2010). Food consumption was based either on existing data for specific food items (Kurita et al., 2009; Cowell and Parkinson, 2003; Risku-Norja et al., 2008; Ostry and Morrison, 2010), or was constructed according to what a nutritious diet should or could be (Peters et al., 2009a; Peters et al., 2007; Vanbers and Robinson, 1993), or by using a combination of both methods (Desjardins et al., 2010). Food production estimates derived from land area cover and agricultural yield data provide high-resolution insight to the geography of food production and population centers. However, the reliability of these estimates is questionable because of local yield fluctuations and errors in land cover data. In contrast, data on food commodity yields are more reflective of food volumes actually produced within a region, but this data is often only available at coarse resolutions—such as national or state/provincial levels. All studies used food consumption statistics, or built an 'optimal' diet based on nutritional recommendations.

*The geography of food production, consumption, and transport*

In the foodshed feasibility literature, the geographical distinction between areas of production and consumption recurs, (see Figure 1), and is largely dichotomized as agricultural and urban areas (Peters et al., 2009a; Peters et al., 2007; Risku-Norja et al., 2008). Within a foodshed, the capacity to meet food need varies by location, and the distance food must travel to meet need varies by size of the population center (Peters et al., 2009a). Within New York State, food for New York City (NYC) travelled ten times as far as food for the average-sized urban center in New York State. NYC accounted for 22% of food distance, though only 4% of food, indicating that feeding large urban centers may require food to travel great distances (ibid). Similar to NYC, the food needs of

Tokyo and surrounding densely populated areas cannot be met locally (Kurita et al., 2009). Risku-Norja et al. (2008) also demonstrate that most of the negative impacts of food production are due to consumption in densely populated urban areas, though consequences, in terms of soil depletion and biodiversity loss, are felt in rural production areas.

One study used a foodshed mapping approach by comparing food needs with production potential based on land cover and soil data in New York State, and using a distance optimization tool to satisfy the most food needs of population centers while minimizing food miles (Peters et al., 2009a). However, these food mile calculations were underestimates, as they were based upon Euclidian distances between production and consumption areas, rather than actual miles travelled through transportation networks (ibid). Regardless, this research contributes the only feasibility analysis that considers transportation distances between various agricultural and urban localities within a foodshed. This represents a significant research gap (see Figure 1), given the degree to which domestic transportation scenarios are discussed in the environmental impact studies (Weber and Matthews, 2008; Mumford, 1956; Pretty et al., 2005). Kurita et al. (2009) analyzed differential production potential within Japan's Kanto Plain by disaggregating food supply and demand into 1 $km^2$ grids and comparing supply/demand ratios. This creates a richer picture than the dichotomous agricultural production and urban consumption areas conceptualized by Peters et al. (2009), however the assumption that supply will be available to immediately surrounding populations ignores the role of retail and distribution networks in the geography of local food. There is no consideration of endogenous transportation or retail networks affecting food availability.

As in the impact studies, environmental concerns are prominent in the feasibility literature. In Finland, 50% of environmental load in the study was due to food production for the area's own consumption needs, and the rest was due to food exported from the area. This implies that increasing the use of local food in the countryside does not significantly reduce negative environmental impacts (Risku-Norja et al., 2008). The inevitable regional imbalance of supply and demand between rural agricultural areas and urban centers perpetuates the negative impacts of agriculture in producing areas. Importing food does not solve the issue, but only transposes it to another area. However, while localizing food consumption does not remove environmental impacts of agricultural production, it likely allows for better control of those impacts, so that more attention and effort will be channeled into alleviating them (Risku-Norja et al., 2008; Cowell and Parkinson, 2003) This opportunity is evident on the fringe of Tokyo, where the mixture of urban and agricultural land uses has spurred problems such as environmental and infrastructure degradation on ecologically important land (Kurita et al., 2009). In particular, controlled urban development and sustainable agriculture practices represent an opportunity to develop local supply and demand networks for rice and vegetables (ibid).

*The role of livestock*

Overall, reducing meat consumption increases the production potential of localized food systems in regions that currently cannot meet food demand with agricultural production. This is because producing animal products requires more land area than growing crops, and also necessitates land area to grow feed (Cowell and Parkinson, 2003; Risku-Norja et al., 2008). However, while plant production may be more efficient per hectare, the presence of land unsuitable for production of other crops, and also feeding livestock on by-products of cash crops, allows for meat to contribute to the carrying capacity of a foodshed (Cowell and Parkinson, 2003; Peters et al., 2007).

Peters et al. (2007) examined how meat and added fats in the average diet affect resource and land requirements, and thereby influence the carrying capacity of New York State as a foodshed. The carrying capacity here refers to the maximum number of people that a foodshed can support, given crop yields, land allocation to different crops, and per-capita food needs for each crop. Carrying capacity can inversely be used to determine the land area necessary to sustain a population of a given size. The authors found a three-fold difference in carrying capacity between different diets, with low-meat and low-fat diets requiring less land than high-meat and high-fat diets. However, the difference between land requirements of diets with different meat levels decreased as fat intake increased. This suggests that increased consumption of fat (determined by the quantities of lean and full-fat dairy and meats, and also plant oils) may lower the carrying capacity of a foodshed among low-meat diets, and will increase carrying capacity among high-meat diets. Though vegetarian diets support more people per unit of land, there is considerable overlap between land requirements of low meat-diets. This is because substituting fat sources away from meat towards plant oils requires use of additional land, and does not capitalize on lands that are only suitable for forage and hay production. Risku-Norja et al. (2008) similarly found that production for low-meat diets supported more people per unit of land, however, this varied by production method rather than fat intake. Specifically with all-organic production, lower crop yields allowed for a diet including beef to make use of forage areas and thereby support more people per unit of land relative to a complete vegetarian diet (ibid).

*Land and production allocation*

All feasibility studies demonstrate that the ability of a foodshed to meet the needs of its local population varies by type of foods produced and physical characteristics of the foodshed that determine production potential. In New York State, production of forage crops for livestock was more equally distributed across space relative to other crops, and so the state had greatest ability to meet local food need for livestock products (Peters et al., 2009a). In Canada, projected capability for grain and oilseed production far exceeds domestic demand, as well as for pulses and potatoes. However, domestic production could only produce 15% of fruits, and 63% of vegetables (Vanbers and Robinson, 1993).

In Waterloo, Canada, local production could meet between 10-100% of optimum recommended intake depending on food type (Desjardins et al., 2010). Seasonal foods with less processing and storage potential (such as melons) had lower feasibility for meeting local need, while seasonally independent foods with high processing and storage potential (such as grains and white beans) could most feasibly meet local need (ibid). In the U.K, consumption is greater than production potential for all foods except cereal and potatoes, while the region is approaching self-sufficiency for meat and animal products (Cowell and Parkinson, 2003). However, an additional 1-16% of current area of agricultural land would be needed for localized production to meet all food needs (ibid). Capacity to meet food need varied between rice and vegetables and geographic location in the Kanto Plain, Japan, with areas of high potential for local production and consumption concentrated in mixed urban/agricultural upland plateaus 50-100 km from central Tokyo (Kurita et al., 2009). There may also be a misalignment between what is demanded or nutritionally suitable for the population, and what is grown, though local crop production may change according to consumer preferences and what is profitable to cultivate (Ostry and Morrison, 2010). This has been the case in British Columbia, which has progressively shifted away from vegetable production towards meat and grains for external trade (ibid).

Across foodsheds assessed in feasibility studies, there is recognized need on the one hand to diversify production to reduce dependence on imports and meet local food need more holistically, and on the other hand to utilize a region's comparative advantage of climatic and soil conditions to specialize in particular products. This has been particularly apparent in BC over the past twenty years, where production of grains and meats has increased to the detriment of fruit and vegetable production, aggravating disconnect between local food production and the nutritional needs of the population (Ostry and Morrison, 2010). To optimize capacity to meet national food demand, Canada's Eastern regions could concentrate on food crops rather than livestock because of climate and rich soils, while Western regions could reallocate some land from grain production towards more mixed production (Vanbers and Robinson, 1993). Localizing primary production for food consumption in a metropolitan region in Finland would require redistribution of land between crops, with less production of cereals, grass, and pastures, and with more area for fruit/berries, oilseed crops, and peas (Risku-Norja et al., 2008). In these studies, technical feasibility of reallocating land for more diversified production is addressed in terms of land availability, soil type, and climatic conditions, while the feasibility of farmers and governments actually implementing these reallocations, given economic or political motivations, is ignored.

## Discussion

To understand if and when pursuing food system localization is a worthy policy goal, there is need for more standardized and holistic analytical procedures for evaluating the impacts and feasibility of local food. This would increase comparability of findings between different localization studies, and also allow consideration of the full range of environmental, social, and economic factors that influence food systems. I focus on the contexts and generative mechanisms governed by parameters like climate, allocation of land between crops as well as livestock feed, production methods, transport methods, storage, and urban development patterns, which all contribute to the varied impacts and feasibilities of localizing food systems observed in this review. I discuss the problems and possible solutions to current approaches encountered in the peer-reviewed literature for studying the mechanisms behind impacts and feasibility of localization, and then highlight emergent trends from this review and their implications for food system planning and policy for local foodsheds.

**Theory and methods**

Local food feasibility studies largely fail to integrate localization's economic, environmental, and social implications that are highlighted in impact studies. Feasibility studies currently employ foodshed analysis to simplify localization as a matter of matching food supply (based on agricultural production potential) with demand (based on current consumption or nutritional requirements). In particular, these studies lack emphasis on market and distribution elements that affect production and trade preferences, as well as transport modes and retail networks that determine food availability.

While all eight feasibility studies encourage reallocation of agricultural land to different crop types within each foodshed to better meet local food demand, these studies do not yet consider the economic impacts of reallocating land in terms of GDP and local food affordability, particularly for reallocation of export crops to other food products. Thus, there is need and potential for development of more sophisticated models to depict economic and social systems, building off the life cycle assessment approach used for single food products in the environmental impact studies. LCA is perhaps the most appropriate approach for evaluating differing impacts and feasibility of local and non-local food systems, because a food product's life cycle will correspond to all elements of a food system: cultivation, processing, storage, distribution, and various modes of transportation. However, LCA is currently limited to evaluating different environmental impacts of individual products within food systems, though could be adapted to assess other social and economic impacts to create more methodological uniformity between feasibility studies. If feasibility studies use more standardized methods in assessing local food systems, then it would be easier for researchers to understand how and why contradictory trends arise in different contexts. Expanding LCA to inform foodshed analysis is an opportunity for feasibility studies to consider a more holistic array of factors that influence localization feasibility.

Another way to improve the accuracy and applicability of local food feasibility studies is to incorporate measures that capture both a foodshed's physical production potential as well as currently overlooked linkages between producers and consumers endogenous to the foodshed. For example, spatial density of direct farm sales was effectively used in a cross-sectional study as a proxy measure for local food production and exchange in the U.S (Timmons and Wang, 2010). The researchers correlated state- and county-level census data with direct farm sales per square mile to infer that relatively high population densities and high median household incomes are needed to sustain small vegetable farms that largely operate through farm-direct sales, such as farmers' markets and community-supported agriculture (CSA) shares (ibid). While this variable does not capture local food systems in their entirety, missing foods that pass through intermediary distributors or retail outlets, it provides valuable insight into population-level characteristics associated with direct exchange between local farmers and consumers. To address current research gaps (Figure 1), feasibility studies could supplement direct farm sales data with survey information collected from farmers on where their output is currently processed (if applicable), and sold. If local food production levels are high and diverse, though foods are sent far away to be processed and sold, this indicates that feasibility of localization is not contingent on geographically congruous supply and demand levels, which feasibility studies currently emphasize, but instead on the establishment of local food processing or distribution infrastructure.

**General trends: Impacts and feasibility of localizing food systems across contexts**

In generating empirical evidence of local food impacts and feasibility, different places will have varying abilities to foster food localization, depending on climate, natural resources and physical infrastructure, population characteristics, and trade linkages (Feagan, 2007; Peters et al., 2009b). Despite the diversity of methods and assumptions employed within impacts and feasibility assessments in this review, certain trends and implications for food system planning and policy emerge.

Meeting food demand with local production is less feasible for large urban areas, as foodshed analysis points out regional imbalances between rural agricultural production and urban consumption. Meanwhile, food-producing areas overwhelmingly bear the environmental impacts of urban food consumption, through soil degradation and air and water pollution (Risku-Norja et al., 2008; Weber and Matthews, 2008). In the food distance optimization study in New York State (Peters et al., 2009a), these regional inequalities in impact could perhaps be reduced by cutting off NYC from domestic food sources (and sourcing all food from imports for the city, abandoning the local food movement). This would greatly reduce statewide food distance travelled from agricultural to the city, while satisfying the food need of geographically disparate populations of New York State more completely. In this regard, a general development model of more diffuse human settlements interspersed with agricultural land, similar to the hinterlands of Tokyo as modeled by Kurita et al. (2009), may reduce food distance travelled to larger urban centers. However, this necessitates that geographically-proximate farmers and consumers are well connected for economic exchange, which was once a norm. For most of human history, the size and location of settlements were constrained by supply of local food in agricultural hinterlands (Mumford, 1956).

Impact studies demonstrate that environmental effects of global and local food miles is not straightforward, as transport by sea can be over 20 times more efficient per kg of produce in comparison to local transport by road (Mumford, 1956; Blanke and Burdick, 2005). Though environmental impact studies differ in their conclusions on the importance of local food transport relative to other elements of the food system, reducing distance that food is transported on local roads will consistently reduce environmental impacts and economic externalities (Mumford, 1956; Pretty et al., 2005; Weber and Matthews, 2008; Blanke and Burdick, 2005).With regards to meat production, there appears to be a threshold effect, beyond which reduced meat production does not greatly

increase land conservation (Risku-Norja et al., 2008; Peters et al., 2009a; Vanbers and Robinson, 1993; Cowell and Parkinson, 2003).
Social impact studies also support the broader claim that developing countries depend on niche marketing of horticultural products in sustaining socio-economic development, and may be harmed by local food movements in industrialized regions (Ford et al., 2011a). From a social justice perspective, food localization within industrialized countries should thus be accompanied by efforts to restructure global agricultural trade linkages, to avoid burdening developing countries with reduced market shares. While the concept of foodsheds and food self-sufficiency is inherently inward-looking, from a global equity standpoint it is important for industrialized countries to consider impacts of food localization efforts on external economic, environmental, and social systems.

## Conclusion

This review began with two basic questions. First, is localization of food systems desirable in terms of economic, environmental, and social impacts? Second, is localization feasible, in that local foods can meet the dietary needs and preferences of a local population? The impact and feasibility studies assessed in this review demonstrate that the answers to these questions vary with agricultural land availability and crop allocation, soil and climatic conditions, urban development patterns, farmers' working conditions, along with transportation and food distribution networks. Across diverse contexts and combinations of parameters, it is difficult to say under what conditions food system localization is a worthy policy goal, insofar as it produces positive impacts on food security, economic and social equity, and environmental sustainability, and is feasible to achieve. Specific trends pertaining to the relative impacts of domestic and international transportation, meat consumption, specialization in particular crops to maximize a foodshed's comparative advantage, or diversifying crops to meet local food need more holistically, are often contradictory between case studies.

To tease out the mechanisms driving these contradictions, either due to contextual difference, or else differing assumptions underlying data analysis, it is necessary to design future impact and feasibility studies in a more standardized way. Impact studies have largely focused on the environmental effects of local food systems with life cycle analysis, a consistent approach that facilitates comparison across particular contexts. However, impact analysis with regards to social and economic systems is less developed, both methodologically and conceptually. These areas are also largely unexplored in feasibility studies, which oversimplify foodsheds as geographical alignment between food production and food demand, ignoring the role of markets. Analysis of additional data such as direct farm sales and other trade information collected from farmers would help to fill this gap. Finally, due to the connectivity of agricultural trade systems endogenous and exogenous to foodsheds, it is essential that localization efforts within industrialized countries work in tandem with foreign governments to account for widespread economic, social, and environmental impacts of localization. To achieve food security and environmental sustainability, the narrow and introspective scope of local food systems research downplays the need for multilateral coordination of global agricultural and trade networks.

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**Appendix**

**Questionnaire: Impacts or Feasibility Studies assessing Local Food Systems**

| | | | |
|---|---|---|---|
| **Title:** | | | |
| **Year:** | | **Author(s):** | |
| **Search:** | | **Journal:** | |

| | | | |
|---|---|---|---|
| **Foodsheds assessed (if feasibility study)** | | **Regions assessed (if impact study)** | |

| | |
|---|---|
| **Research question** | |
| **Data sources** | |
| **Methods** | |
| **Assumptions** | |
| **Key findings** | |
| **Comments on study quality** | |
| **Relevant references** | |

**Table 1: Impact Studies**

| Authors | Pub Date | Title | Journal | Region* | Impact Measured | Analytical Approach |
|---|---|---|---|---|---|---|
| Ballingall & Winchester | 2010 | Food Miles: Starving the Poor? | World Economy | Global | Social (Welfare changes) | Global economy model, augmented by food preference |
| Blanke & Burdick | 2005 | Food (miles) for thought - Energy balance for locally-grown versus imported fruit | Environmental Science and Pollution Research | Apples: Germany (local), New Zealand | Environmental (Energy) | Life Cycle Assessment |
| Cross et al. | 2009 | Does farm work health vary between localised and globablised food supply systems? | Environment International | U.K (local), Spain, Kenya, Uganda | Social (Farmer health) | Self-reported health questionnaire |
| Pretty et al. | 2005 | Farm costs and food miles: An assessment of the full cost of the UK weekly food basket | Food Policy | U.K | Economic (Environmental costs) | Quantification of externalities or "full cost" |
| Schlich & Fleissner | 2005 | The Ecology of Scale: Assessment of Regional Energy Turnover and Comparison with Global Food | The International Journal of Life Cycle Assessment | Juice: Germany (local), Brazil, European countries Lamb meat: Germany (local), New Zealand | Environmental (Energy) | Life Cycle Assessment |
| Sim et al. | 2007 | The relative importance of transport in determining an appropriate sustainability strategy for food sourcing | The International Journal of Life Cycle Assessment | Apples: Brazil, Chile, Italy, U.K; Runner beans: Kenya, Guatemala, U.K; Watercress: U.K, U.S | Environmental (9 different variables) | Life Cycle Assessment |
| Weber & Matthews | 2008 | Food-miles and the relative climate impacts of food choices in the united states | Environmental Science & Technology | U.S: 8 different food groups | Environmental (greenhouse gas emissions) | Life Cycle Assessment |

*Countries followed by (local) indicate that food produced in this country is considered ‘local’ relative to other countries in the study.

**Table 2: Feasibility Studies**

| Authors | Pub Date | Title | Journal | Scale of Foodshed | Study Period | % Self-Sufficient |
|---|---|---|---|---|---|---|
| Desjardins et al. | 2010 | Linking future population requirements for health with local production in Waterloo Region, Canada | Agriculture and Human Values | Municipality + region (Waterloo, Canada) | Projection 2026, using 2006 data | Depending on food type: 10-100%, |
| Vanbers & Robinson | 1993 | Farming in 2031 - A Scenario of Sustainable Agriculture in Canada | Journal of Sustainable Agriculture | National & sub-regional (Canada) | Projection, 2031, using 1986 data | 15% fruits, 63% of vegetables |
| Peters et al. | 2007 | Testing a complete-diet model for estimating the land resource requirements of food consumption and agricultural carrying capacity: The New York State example | Renewable Agriculture and Food Systems | State (NY) | 1999-2003 (crop yield data) and 2000 (census population data) | 21% of population, assuming 30% fat, 190 g meat diet per day |
| Peters et al. | 2009 | Mapping potential foodsheds in New York State: A spatial model for evaluating the capacity to localize food production | Renewable Agriculture and Food Systems | State (NY) | 2000 (census population data), 1992 (land use data) | 34% overall. NYC had 2% of food need met. Other urban centers had 98% of food need met |
| Ostry & Morrison | 2010 | A Health and Nutritional Evaluation of Changes in Agriculture in the Past Quarter Century in British Columbia: Implications for Food Security | International Journal of Environmental Research and Public Health | Provincial (BC) | Change in productive capacity, 1986-2006 | Depending on food type: 39-267% (1986), 13-251% (2006) |
| Cowell & Parkinson | 2003 | Localisation of UK food production: an analysis using land area and energy as indicators | Agriculture, Ecosystems & Environment | National (UK) | 2006 | 84-99% |
| Kurita et al. | 2009 | The potential of intra-regional supply and demand of agricultural products in an urban fringe area: A case study of the Kanto Plain, Japan | Geografisk Tidsskrift-Danish Journal of Geography | Municipality + region (Kanto Plain, including Tokyo and other municipalities) | 2005 | 50% of all urban areas had potential for self-sufficiency for rice and vegetables at the municipal level |
| Risku-Norja et al. | 2008 | Localisation of primary food production in Finland: production potential and environmental impacts of food consumption patterns | Agricultural and Food Science | Municipalitiy (Juva, Finland) | 2003 | >100% |