PERSPECTIVES FROM STAKEHOLDERS ON THE FOOD-ENERGY-WATER NEXUS IN METROPOLITAN SEATTLE

Table of Contents

Abstract

Food, energy, and water (FEW) are deeply intertwined in modern agricultural production, consumption, and management. Policies aimed at increasing local food production and consumption are likely to affect all three FEW sectors as well as the practical and economic relations of producers and consumers to those sectors. This publication synthesizes interview data collected in the summer of 2016 to provide a snapshot of the thoughts of food producers, major agricultural commodity buyers, and policy-makers on topics related to food, agriculture, land-use planning, and energy and water resources around an urban setting. We found that connections between water and food production were well understood by northwestern Washington stakeholders, whereas connections between energy and food and water and energy were less understood or discussed. Many interviewees expressed a desire to work toward improved coordination and collaboration across agencies and organizations, to set goals for sustainable food production in the region, and to address institutional barriers to meeting those goals. Two competing, but not mutually exclusive, visions for a more sustainable regional food system emerged from interviewees: a sharp urban-agricultural boundary vision and a mixed urban-agricultural boundary model. These two models often are at odds with actions of key local agencies. Additionally, it was not clear if a strong, local desire for local food would enhance or exacerbate future food, energy, and water resources.

WASHINGTON STATE UNIVERSITY EXTENSION

Introduction

The past hundred years have seen substantial changes in how society manages food, water, and energy. Climate change, population growth, urbanization, and dependence on international trade have all increased the demand for food, energy, and water (FEW) resources and have increased the complexity of FEW management decisions. As the uses of these resources have changed, the food, energy, and water sectors have become highly interdependent on one another for continued productivity, yet these resources are rarely managed in close coordination.

In the late nineteenth and early twentieth century, urbanization and accompanying industrial development revolutionized approaches to agricultural production and energy and water management. At the time, it was economically, technically, and institutionally efficient to manage FEW resources individually, in a compartmentalized manner (Figure 1a). As the global population has increased and the pace of technological development quickened, growing demands for food, energy, and water resources have amplified the complexity of FEW management decisions and increased the severity of unintended consequences across management sectors (Figure 1b). For example, when the original Columbia River Basin Treaty was signed between Canada and the United States in the middle of the twentieth century, management contingencies were defined exclusively in terms of hydropower and flood control goals. Managers did not explicitly consider implications for food production systems or wildlife habitat. The renegotiation of the Columbia River Basin Treaty, currently underway, has incorporated a much broader set of "FEW Stakeholders" than were originally engaged to include environmental interests, tribal groups, and irrigators (Brady et al. 2015). Translating this diversity of interests into the rules that manage dam operations will require coordinated and integrated management plans of much greater complexity than has been employed in the past if future human and environmental demands for resources are to be sustainably met (Figure 1c).

Priorities and approaches in managing FEW resources vary across local, state, regional, and federal agencies. Urban areas are hot spots of consumption of FEW resources (i.e., resource sinks). When food is imported to feed an urban population, it is embedded with the water and energy resources that were used elsewhere to produce, process, and transport it. Increasing local food production could decrease these expensive, global, embedded resource flows, but may utilize more of the local energy and water resources for local food production and processing, thereby diverting those locally-limited and over-allocated resources from other societally beneficial uses (e.g., municipal and industrial uses, in-stream environmental needs).

In this publication we present findings from a series of structured interviews conducted in the summer of 2016 with 27 stakeholders across the FEW nexus and from across northwestern Washington. The stakeholders included food producers, major agricultural commodity buyers, and policy-makers in the FEW sectors. Interview questions focused on food, agriculture, land-use planning, and energy and water resource management as related to "local food" in the Puget Sound region. Our goal was to provide a point-in-time, cross-sectional understanding of factors that influence decisions about FEW systems use and management, and of emerging concerns, conflicts, and policies in Washington State. The Seattle metropolitan area, and specifically King County, was selected as a case study to better understand the perspectives of key stakeholders and to identify core factors related to FEW resources that are involved in producing local food and meeting urban local food demand.

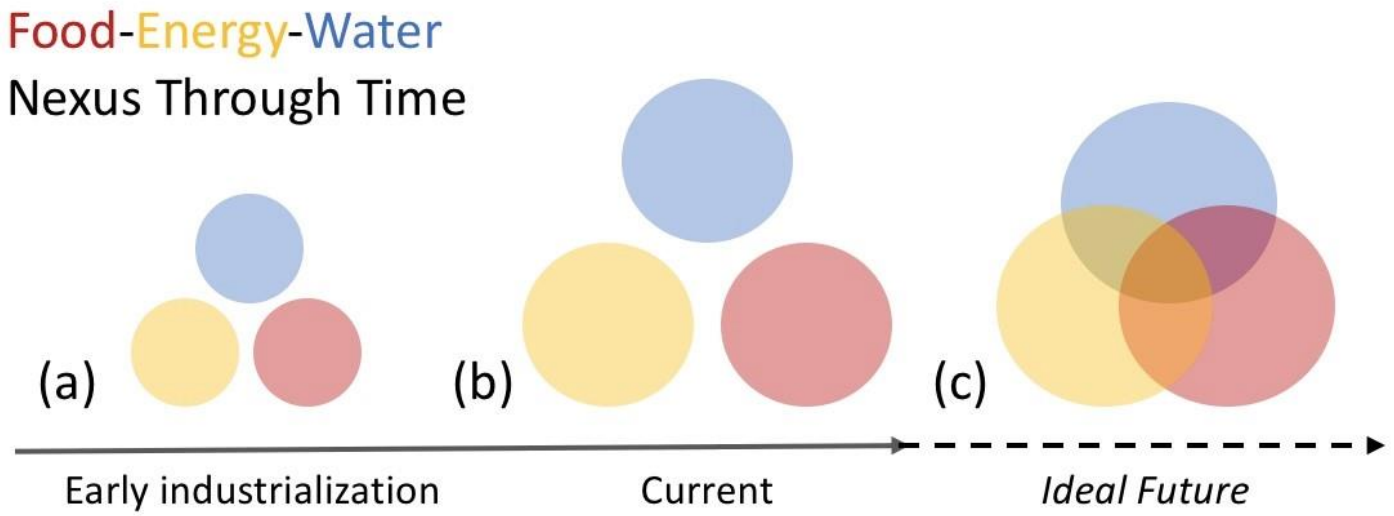

Figure 1. Conceptualized trajectory of food, energy, and water (FEW) nexus over time. Image adapted from Katz et al., 2020.

Recognizing Food-Energy-Water System Interconnections

The interconnected nature of the food, energy, and water sectors has long been recognized, but it is only recently that the term "nexus" has been employed to describe the three sectors as a connected system and to operationalize this connectivity for management and scientific advancement (Liu et al. 2017). One challenge with the nexus approach is identifying the different spatial and temporal boundaries within which each FEW component exists. Not only do the ecological boundaries of food, energy, and water often not align but the geographic and administrative boundaries for each sector do not always align either (Perrone et al. 2011). It becomes useful to analyze the interaction of the FEW nexus within a domain that encompasses the dominant utilities that govern each resource, such as urban areas (Perrone et al. 2011). Food, energy, and water are primary imports into urban systems (Decker et al. 2000), and the sectors are typically managed independently rather than as an integrated system. Taking a systems approach and explicitly considering the nexus can help create optimal and efficient resource utilization and reduce negative impacts to human well-being and the environment (Hoff 2011; Ringler et al. 2013).

The three FEW sectors are interrelated in multiple ways, but the way the nexus is characterized depends on the perspective brought to the discussion, which often has a primary focus on one sector with the others acting as inputs, resource users, or outputs (Bazilian et al. 2011). For example, from a food perspective, water and energy are considered inputs; from a water perspective, food and energy are resource users; and from an energy perspective, water is generally an input and food is an output. The interactions among the sectors are strong and complex (Pittock et al. 2013), and competing demands for resources can exacerbate systems-level trade-offs and are the basis for the calculation of opportunity costs (Leck et al. 2015). Understanding how changes to one sector impact and influence the other sectors is critical to evaluating synergies and trade-offs across sectors. Some examples of trade-offs are:

- Demand for more biofuel production could lead to increased demand for oil seed crops. This "win" in the energy sector might be linked to fertilizer runoff and intensive water use that negatively impacts water quality and quantity and land availability for food crops.
- Converting dairy manure to fuel in anaerobic digester systems may reduce methane emissions (a powerful greenhouse gas) and increase the supply of locally produced renewable energy, but waste from such systems may lead to degraded local water quality.
- Growing food crops indoors could expand local food production in urban areas and extend the seasonal availability of fresh, local produce while taking advantage of increased water availability in off-seasons (i.e., non-summer) but could be costly in terms of energy usage to maintain building climate control.
- Expanding water access for food crop irrigation could necessitate curtailment of water for municipal use, hydropower generation, and in-stream ecosystem flows.

There is potential for synergies among FEW sectors and resources as well. For example, co-development of natural gas power plants and indoor greenhouse production systems could potentially allow waste heat and CO_2 emissions from the power plants to be channeled into the greenhouse, thereby reducing the energy needs for greenhouse climate control.

The U.N. Food and Agriculture Organization (FAO) has identified three main working areas to enhance FEW management, which they suggest should be developed directly through stakeholder dialogue: (1) evidence, (2) scenario development, and (3) response options (Food and Agriculture Organization 2014). This publication synthesizes the first phase of such stakeholder interviews and dialogue on the FEW nexus at nested scales in Washington State. The goal of the interviews was to begin to establish the spatial boundaries of the connected FEW system as it relates to meeting local food demand in the greater Seattle area.

Regional Context

The western United States is the most urbanized region of the nation, with nearly 90% of residents living in urban communities (U.S. Census Bureau 2010). Large metropolitan communities are surrounded by very low-density, rural areas and expanses of federally owned land. In Washington, nearly 85% of residents live in urban communities (U.S. Census Bureau 2010). Population growth and increased urbanization is occurring at nearly every geographical scale. Seattle is one of the fastest growing cities in America, having added an average of 57 people per day from July 1, 2015, to July 1, 2016 (Balk 2017). In 2015, the population of the central Puget Sound region grew by 2.2%, the highest growth rate in the past 20 years (Puget Sound Regional Council 2016). King County's population is expected to grow from about 1.9 million people in 2010 to about 2.4 million people in 2040 (Seattle Office of Planning and Development 2016). Consideration of FEW resource interactions is vital in the context of this rapid regional change.

Resource challenges from population growth are exacerbated by climate change impacts. Climate change is projected to reduce water availability during the peak growing season in the Pacific Northwest due to changing precipitation regimes and less water being stored as mountain snowpack (Chang et al. 2013; Luce et al. 2013). Still, the Pacific Northwest region is relatively fortunate with a less severe drought outlook (Strzepek et al. 2010), less severe agricultural production impact outlook (Rajagopalan et al. 2018), and well developed irrigation infrastructure (Neibergs et al. 2018), as compared to many other regions. In this context, Washington may become an even more critical agricultural area for feeding the nation as other regions become less suitable for some types of agricultural production (Eigenbrode et al. 2013; Rajagopalan et al. 2018; Rosenzweig et al. 2013). This transition will bring to the region and state both economic opportunities and raise serious concerns about energy, water, land use, and agriculture-related pollution.

Nationally, Washington State already provides significant production of various agricultural commodities, with specific counties dominating supply of specific commodities: wheat, tree fruit, and vegetable production are dominant on the east side of the Cascades; counties west of the Cascades provide significant milk production (Whatcom, Skagit, and Snohomish counties), raspberries for the processing market (Whatcom county), and vegetable seed production (Skagit and Snohomish counties) (USDA 2012). Average farm size also varies greatly by county and longitude: farms in eastern Washington are typically much larger than farms in western Washington counties (USDA 2012).

Recent food policy initiatives in the Seattle metropolitan region aim for an increase in local food production and consumption and increasing local agricultural diversification. For example, the Seattle City Council passed the *Local Food Action Initiative* in 2008, aiming to: (1) reduce food waste and increase composting of non-edible food, (2) support small businesses that grow, process, and distribute local and healthy food, (3) prioritize food production as a valued use of land, and (4) increase the affordability and accessibility of healthy food for all Seattle residents (City of Seattle 2012). The King County Executive's *Local Food Initiative* was introduced in 2014 to connect local farmers and consumers, increase access to healthy and affordable foods in underserved areas, increase diversity of production, increase the consumption of local production to improve its profitability, protect existing farmland, and implement strategies to improve resilience to the effects of climate change (King County 2015). Specific ten-year targets put forth include: (1) adding 400 net new acres in food production per year in King County (2% per year), (2) increasing the number of new and beginning farmers in King County by 25 new farmers per year, (3) doubling demand for locally produced, healthy food from $93 million to $186 million, (4) reducing the amount of wholesome food loss by 25%, and (5) increasing consumption of fruits and vegetables among both youth and adults (King County 2015).

King County has five agricultural production districts (APDs), which encompass 42,000 acres of prime farmland (Figure 2). Agriculture is supported within the APDs through zoning and building code limitations designed to protect agricultural soils (King County 2015). Farming operations in King County are diverse, with agricultural plots ranging from large commercial forage producers to several-acre organic vegetable farms and urban agriculture operations that are smaller yet. Stakeholders in this study estimated that nearly 80% of the actively farmed land in King County is used for livestock production in some form (e.g., dairies, pasture, or forage production) and that land growing market crops (non-irrigated flowers, irrigated specialty and organic vegetables, berries, orchard fruits, and wine grapes) accounts for 5% of the APD area. Based on the 2012 National Agricultural Statistics Survey, King County has the largest number of vegetable farms, 245 in total, of any Washington county. However, the total acreage planted to vegetables in 2012 was just 984 acres, for an average farm size of four acres (USDA 2012). The gross salable market value of fruit and vegetable production in King County was estimated at $20 million in 2015 (King County 2015).

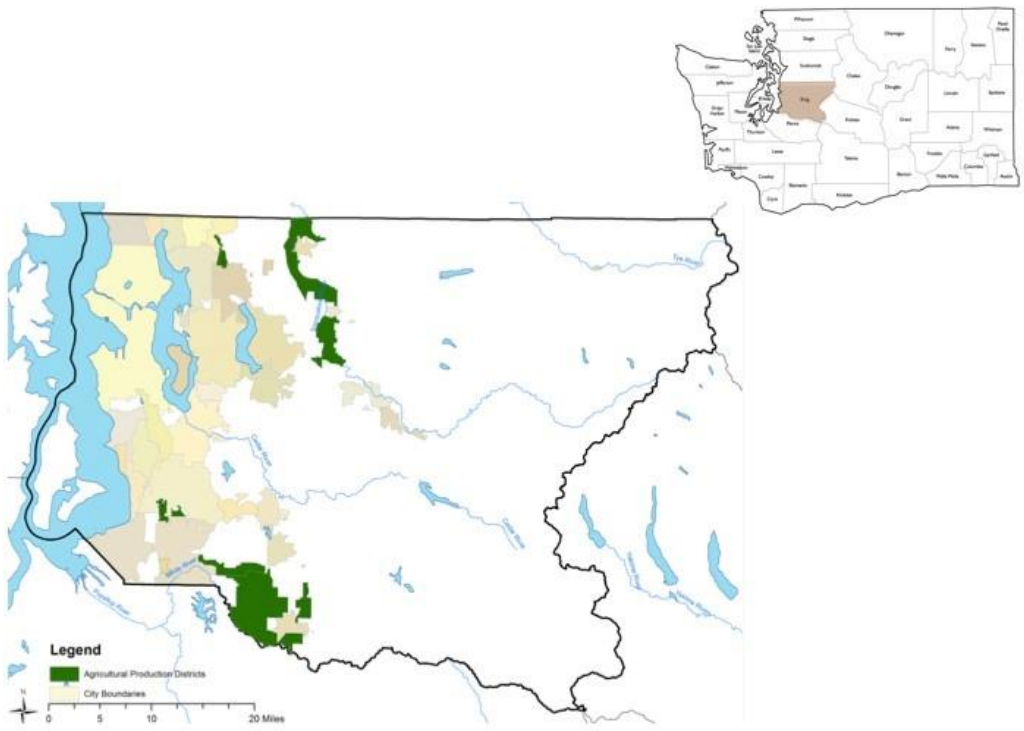

Figure 2. Location of King County in Washington State (top) and locations of Agricultural Production Districts (APDs) in King County (bottom). Image by Sasha Richey; data provided with permission by King County.

Methods

We interviewed stakeholders with a wide range of professional roles and perspectives on FEW resource management from across northwestern Washington, around Seattle, and Washington State. We sought to speak with individuals representing each of four general groups: (a) food producer representatives, (b) food consumer representatives, (c) energy and water policy decision makers, and (d) food policy decision makers. From nearly 200 individuals we identified as members of the four stakeholder groups, we invited 50 individuals to be interviewed. A total of 27 semi-structured phone interviews were conducted during the summer of 2016.

- *Producer representatives* (seven individuals) were individuals in northwestern Washington who produce food or work closely with agricultural producers to develop farm management plans or to bring their products to markets.
- *Consumer representatives* (five individuals) were individuals experienced with concerns and priorities driving Seattle area residents' food purchasing decisions.
- *Energy and water policy decision makers* (eight individuals) were individuals who make natural resource management policy decisions at municipal, county, and statewide scales.
- *Food policy decision makers* (seven individuals) were individuals focused on agricultural policy or, separately, food access policy.

Each of the stakeholder interviews was organized around 12 questions designed to document interviewees' background information about professional roles and responsibilities, perceptions of drivers of system behaviors, expectations and goals for the future, and thoughts about management challenges and barriers to implementing changes in FEW systems management. Semi-structured interviews followed the protocol outlined by Creswell (2007). The interviewer used follow-up questions to understand specific points made by interviewees. Interviews were transcribed and analyzed using NVivo software for qualitative data analysis. A pattern coding approach (Saldana 2009) was employed to identify and group statements from interviews into key themes. For example, all mentions of policy goals were grouped together, allowing for analysis of the most frequently expressed policy goals. The interviews generated a wealth of information about how Seattle-area stakeholders were thinking about "local food" and what opportunities and challenges there are for local food production and distribution, equitable food access, and related FEW policies.

Findings from Interviews

Competing Visions of a Sustainable Food System Future

Seattle-area stakeholders expressed multiple visions of an ideal food system for the future, each of which implies different patterns of future FEW resource uses and interactions. Broadly speaking, stakeholders expressed support for the goal of increasing food production in King County and western Washington, and for the goal of increasing consumption of locally produced food in the Seattle area. However, two distinct visions of an ideal regional food production future emerged from among the interviewees: a densely urbanized region should be surrounded by highly productive larger farms (Figure 3, top) versus a smaller urban core should be surrounded by green space used for food production interspersed through the residential zones (Figure 3, bottom).

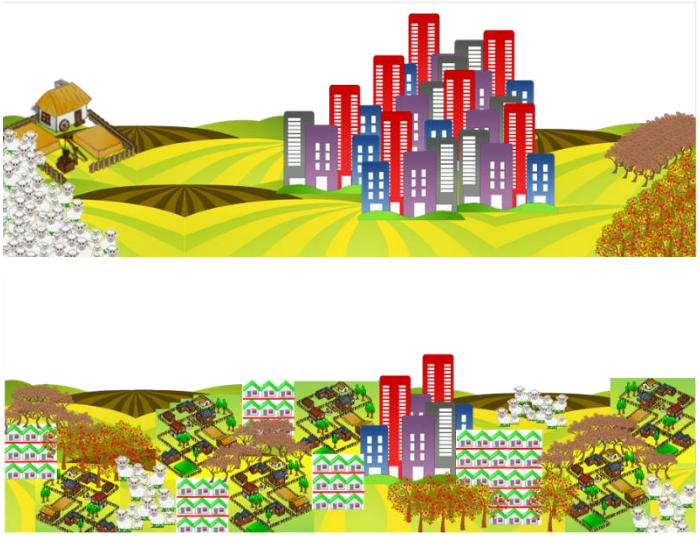

Figure 3. Alternative conceptual models of urban relations to local food production: the sharp urban-agricultural boundary model (top) and the mixed urban-agricultural model (bottom). Image by Kevan Moffett.

Advocates for a *sharp urban-agricultural boundary model* (Figure 3, top) felt that sprawl is a serious concern. These stakeholders would like to maximize the efficiency of local food production by scaling up farming operations to try to meet a higher proportion of food demand locally. They expect that larger farms will be more effective at implementing technologies to efficiently use water and energy. Some stakeholders see larger local farms as a more likely pathway toward decreasing reliance on agricultural products from outside the region. They expect that larger farms will have greater capacity to supply grocery chains and distribution companies with local produce and presume that economies of scale could support increased local food processing for out-of-season consumption. Interviewees also noted FEW trade-offs; for example, increasing local food processing could increase local energy and water use while reducing transportation energy use.

Advocates for a *mixed urban-agricultural model* (Figure 3, bottom) focused on the social and cultural benefits of urban and local food production. These stakeholders stated that it is important for consumers to strengthen their connection to the people who grow their food and to better understand the landscape processes and environmental considerations associated with agriculture. Stakeholders in favor of mixed urban-agricultural development emphasized the value of policies that support small- and midsize producers to process and sell products locally. They generally focused less on the amount of

local production and more on supporting practices that conserve soil and water resources.

Many stakeholders did not see these two visions of the future as mutually exclusive and stated a desire to see opportunities for farms of all sizes throughout the region. It is believed that different patterns of urban and agricultural development may be appropriate for cities of different sizes or different environmental settings.

At the same time, several stakeholders expressed frustration that agencies and organizations are occasionally working at cross-purposes by supporting different visions via zoning, farmland preservation policies, taxation structures, and infrastructure investments. It was felt that without a clearly defined and unifying vision it will be difficult for regional agencies to develop effective policies that work across local jurisdictions.

The goals for future agriculture policy expressed in the interviews seemed to reflect stakeholders' areas of expertise. The policy goals most frequently expressed by the 27 interviewees were to:

- Expand public and private farmland preservation programs.
- Focus on maintaining urban density and fighting sprawl.
- Preserve green space and utilize open space for food production.
- Preserve soil quality on farmland for drainage and carbon storage benefits.
- Reward food production in urban spaces, residential spaces, and on farmland.
- Maximize the efficiency of food production.
- Pursue neutral or positive impacts on soil quality, water quality, and air quality.
- Preferentially support certain types of agricultural production (e.g., incentivize fruits and vegetables over forage production, use of grain as a cover crop, promote local wheat or organic meat).
- Designate land currently zoned for agriculture as working land in the Washington State Growth Management Act so that agricultural lands are protected under state, as well as county, laws and regulations.
- Expand institutional markets for local food, including hospitals, universities, businesses, and large restaurant chains.

Perceived Threats to King County Agricultural Production

Stakeholders emphasized that the challenges that most concern agricultural producers in Washington State vary greatly depending on the local climate, topography, zoning, and natural resource policies. The challenges also vary greatly depending on the producer's personal background, values, and business model. For example, stakeholders whose work focuses on vegetable production for local markets have different perspectives on the most significant policies and challenges than stakeholders who focus on livestock or forage production.

Across all interviewees, when asked about threats to the sustainability of the regional food system supporting the Seattle metropolitan region, three major threats were mentioned in the context of the food-energy-water nexus: (1) climate change, (2) access to water, and (3) flooding.

Climate change was a prominent topic in stakeholders' minds when reflecting on challenges for the regional food and agricultural systems. Agricultural producers noted that rising temperatures and changing precipitation patterns have many possible consequences for crop growth and quality. Expected impacts of regional temperature increase included increased crop water demand, less reliable summer water availability because of reduced snowpack, early season flooding, earlier harvest dates, and changes in pest and disease pressures. Concerns were expressed about the potential for increased incidence of extreme weather events, droughts, and flooding, all of which would add even greater uncertainty to the already high-risk business of farming. In contrast, among interviewees representing the consumer group, climate change was not frequently identified as a threat to regional food production.

Access to water for irrigation is already a concern for many producer stakeholders. Interviewees noted that King County underwent a shift in the late 1970s and early 1980s when many dairies closed and the number of small fruit and vegetable producers began to expand. As livestock farms converted to crop production, some farms came with water rights, but many did not. In navigating the water rights system, some farmers have been able to lease water while others have shifted to growing unirrigated flowers or are using exempt wells. Interviewees noted that in typical summer conditions farmers without access to groundwater are still able to grow flowers and some other crops if they are located close to a river where soil holds sufficient moisture. However, in drought years those farms are at risk of substantial losses. Climate change is expected to intensify such challenges for unirrigated farms.

Flooding is a serious management challenge across western Washington, for both producers and government agencies. The challenges for producers are direct and severe. For example, federal Food and Drug Administration regulations prevent food crops that have been touched by floodwaters from being harvested. Being in a floodplain limits where farm infrastructure can be developed and where homes for farmers can be built. Also, some cropping insurance options are not available to growers in floodplains. Yet, ironically, floodplain soils are fertile, hold water well, and may have a shallow water table that can help keep crops moist in dry seasons, even without irrigation. Floodplains may also be even less optimal or sustainable locations for alternative land uses such as residential, commercial, and industrial development. As demand for year-round local food increases and efforts are made to expand the growing seasons of in-demand agricultural products, flooding, more typical in the more marginal early spring and late fall seasons, may become an even more significant issue.

Within each of the stakeholder groups, interviewees identified additional threats to regional food system sustainability that were more specific to their experiences:

Producer representatives focused on challenges that small- and midsize producers face in scaling up their operations and in maintaining viable business models. These stakeholders detailed specific zoning and taxation policy changes that they believed would best support increased food production in western Washington. Access to irrigation water and managing flood risks were highlighted as central issues that drive producers' decisions.

Consumer representatives perceived a stable, but not necessarily growing, interest in locally-produced food. They perceived that the public generally has limited awareness of water and energy issues associated with agriculture. Individuals who purchase locally-grown food were perceived to do so because they hope to help generate community-building and economic benefits by supporting local producers, and because they feel local food products are higher-quality than non-local products.

Energy and water policy decision makers highlighted management challenges related to frequent flooding of King County farms, trade-offs between preserving riparian zones for salmon habitat and allowing riverbanks to be developed as farmland, and potential impacts of increasing irrigation efficiency. Water managers were hopeful about the potential for residents in farming communities to engage in Watershed Improvement Districts and participate directly in managing water resources in their local communities. It was also noted that tools for water management have become less flexible following Washington State Supreme Court rulings related to impairment, for example, reductions in water availability for meeting in-stream flow targets or allocations for other users (Sessions 2016).

Food policy decision makers perceived programs that support farmers and farmland preservation as highly important. They expressed a need to balance resource allocation both to support today's farmers and to ensure long-term preservation of agricultural lands and land productivity in the region. They identified market forces (e.g., corporate grocery chains) and federal policies (e.g., subsidies for select commodities) that perpetuate existing agricultural practices. These market and federal policy forces place some constraints on the local food and agricultural policies that can feasibly be developed and implemented.

Perspective on the Value of Locally Produced Food

Stakeholders recognized that the majority of food consumed in the Seattle metropolitan area comes from large, national grocery chains and restaurant chains. While the region has a robust network of producers, processors, and innovative food companies, stakeholders frequently noted that farmers markets, Community Supported Agriculture (CSA) shares, and direct farm sales remain the exceptions to where most of the urban population purchases food. Less than two percent of the nearly six billion dollars King County residents spend annually on food and drink is grown within King County (King County 2015). Still, interviewees perceived Seattle residents to be among the nation's leaders in their interest and support for a local food culture. Organic and sustainably produced foods were noted as important to many area consumers, and supporting local farmers noted as a priority for some shoppers. Interviewees were divided on whether Seattle's market for locally produced food was saturated or growing.

Increasing the proportion of the Seattle-area food supply that is locally produced was a desirable goal according to many of the interviewees. At the same time, many stated that sustainable production is a more important value than hyper-local production. Interviewees recognized that sourcing all Seattle's food from within King County, or even within Washington State, is not realistic given consumer demand for products that cannot readily be grown year-round in Washington. There was a widespread view that policy makers and consumers should focus on supporting efficient food sourcing, in other words, make decisions based on regional suitability and resource constraints. Themes among the perspectives from different stakeholder groups on the value of local food production are outlined below.

Producer representatives tended to prioritize food production being environmentally responsible and economically practical, whereas selling locally was generally not a top priority. Many producers who sell at Seattle area farmers markets bring goods from farms on the urban fringe, but some travel from as far away as central and eastern Washington.

Consumer representatives noted that some individual food shoppers in Seattle may feel that local food is "anything produced within 150 miles of the city;" however, that definition eliminates most of Washington's apple production, which they also consider "local." A typical Seattle grocery shopper's definition of "local" may also change with the seasons, eating more local products during the local harvest season and expanding more regionally or globally during off-seasons. However, many shoppers lack knowledge about which foods can be grown locally and during what seasons they are available, or may not value the distinction, and so do not differentiate or discriminate between local and non-local products. When individual food shoppers place a high value on local food production, it is often because they feel locally produced foods tend to be fresh and flavorful, and they assume it to be sustainably produced or more environmentally friendly; they are most likely equating this to food-miles calculations and some of the energy resources used for transportation. Local fresh produce, meat, and dairy products are generally higher priorities for individual Seattle-area shoppers than are locally produced grains and packaged foods.

Energy and water policy decision makers emphasized that the prior appropriations rule governs water access in Washington. There are currently no legal mechanisms for giving preference to water use for local food production. The energy costs associated with transporting food are an important consideration, especially for non-local production. However, despite the energy demands of production, the largest energy cost category in the local food system may be consumers driving their personal vehicles to grocery stores, markets, or farms to pick up their farm stand or Community Supported Agriculture (CSA) share.

Food policy decision makers in several instances noted that focusing on definitions of local may distract from more critical food and agriculture policy issues, including equitable food access, energy and water use, and general sustainability of farming operations. Some food policy stakeholders said that the definition of local should vary by crop. For example, many interviewees expressed the view that sourcing Seattle's wheat from the prime wheat producing areas of eastern Washington is a logical and important goal. Many interviewees expressed the view that production, processing, distribution infrastructure, and consumption patterns should be adapted so that more Washington-grown products stay within the region rather than being shipped internationally. For many policy makers, supporting local food is an important value, because it is linked to the additional important objectives of preserving open space and preserving the livelihoods of farmers in rural communities.

FEW Trade-Offs Related to Increasing Local Food Production

Interviewees were asked, "What do you see as potential drawbacks, if any, to increasing food production for local markets?" In general, interviewees did not project any explicitly negative aspects of local food production. However, some stakeholders did say that supporting local food production could have trade-offs for water use, energy use, habitat protection for native species, and other social and environmental goals. Potential trade-offs that stakeholders identified within the FEW nexus that might be associated with increasing local food production for Seattle follow.

Food-water trade-offs:

Increasing local food production is assumed to require increased water usage for irrigation, unless substantial increases in efficiency are invented, incentivized, or implemented. At the same time, the region continues to experience rapid population and industrial growth within the context of a shifting climate and declining snowpack. Regional decision-makers must contend with projections of shifted water seasonality and a water-scarce future.

Existing water allocation laws and mandated conservation of endangered Chinook and Coho salmon, steelhead, and bull trout are at the core of many concerns for a water-scarce future and food-water trade-offs. Policies cannot necessarily preserve in-stream water flows for fish and support intensive irrigation at the same time. Water quality impacts of agricultural production are also a concern for fish, other aquatic organisms, and downstream human water users. Interagency planning and management boards currently play an important role in bringing agricultural and wildlife conservation interests together to develop locally-appropriate conservation measures and educate landowners about regulatory issues.

Choosing to increase local food production may necessitate trade-offs with water use in other sectors. This may require water conservation policies to be enacted and enforced on other uses, such as watering lawns and home gardens.

Stakeholders explained that water management options are now somewhat less flexible due to recent court rulings related to impairment of water rights, for example, reductions in water availability for meeting in-stream flow targets or allocations for other users (Sessions 2016). To enhance desired flexibility, groups of producers are seeking to collectively manage water resources, establishing Watershed Improvement Districts (WIDs). WIDs are a policy mechanism that has been in place since early in Washington State history, but the use of which has lapsed for some time. Some stakeholders viewed these refreshed WIDs as an important aspect of a hopeful future for the water-food nexus.

Meeting overall water demands in the future may increasingly mean using reclaimed wastewater for food production. Stakeholders expressed a range of perspectives about the potential use of reclaimed wastewater for irrigation. Some described current pilot projects in King County using reclaimed wastewater to irrigate non-food crops, golf courses, and playing fields. The concept raised some concerns regarding public health and safety. Many stakeholders stated they did not yet have enough information about the potential benefits and concerns of irrigating crops in western Washington with reclaimed wastewater to evaluate the option.

Food-energy trade-offs:

For many stakeholders, the connection between food production and energy resources was less easily defined than the connection between food production and water resources. Energy costs related to pumping water for irrigation did not come up in interviews. Management of reservoirs for hydroelectric energy production was not generally seen as being in conflict with goals of water resources management for agricultural production.

The city of Seattle has committed to offsetting any new electrical load growth by true conservation and use of renewable energy. Within Seattle City Light, the urban electrical utility, there is a program to purchase carbon credits to offset greenhouse gas emissions from its operations, facilities, and city vehicles. In the future, new ties may form between energy and agriculture, for example, expanded opportunities to reward and incentivize carbon storage in farmland soils and action on current interest in dairy methane as a source of renewable energy.

The possibility of expanding indoor food production to provide local food from within the Seattle metropolitan area raised questions about the consequent energy needs. Additional questions considered what the relative costs and benefits would be of growing locally in a climate controlled environment with municipal water compared to less locally, outdoors, and with stream or ground water. Stakeholders described interest in test projects, uncertainty about building and energy costs, and uncertainty whether indoor urban production can be profitable enough to justify the costs.

The transportation-related energy cost of food consumed in the greater Seattle area was of interest to many stakeholders; however, a lack of available data about food transportation was frequently mentioned. The possibility was raised that consumers driving personal vehicles to purchase food may be the most significant energy cost in the system.

Economic and Other Considerations Related to Increasing Local Food Production

Economic local food considerations

The price paid for food by consumers does not represent the complete cost of producing, processing, and distributing food. For example, the price the consumer pays likely does account for the costs of fuel used by the farmer to produce food and by distributors to transport food. The environmental costs of emissions from burning fuel, however, are not generally included in food purchase price and are instead paid via other mechanisms by society as a whole. In the case of water used in production, some water becomes part of the food product or is evaporated from fields. The monetary cost of water resources is often low, per unit volume. There may be additional environmental costs of water use, however, such as diminished fishery populations due to diverting water out of streams, or nutrient and pesticide movement from fields to streams, or groundwater causing damage to ecosystems and public water supplies. Some of the costs of water and energy are paid by the end consumer via the price of the good (internalized), but many are not. True cost accounting attempts to tally these externalities to give consumers a more balanced view when making food choices.

Awareness that the full cost of food consumption is not reflected in the price paid may be one motivation for consumers to prioritize buying food produced more locally, within their county or state. A Seattle resident may feel that they have little consumer or voter power to influence, for example, unsustainable agricultural groundwater withdrawal in California or Nebraska. They might choose, however, to avoid purchasing food produced in those states to avoid potentially supporting a perceived unsustainable system. In contrast, a Seattle food consumer is also likely to be a Washington State voter and may feel they have a greater ability to influence local agricultural policy and environmental management via the combination of their local or state shopping and voting actions. The idea of the voter-consumer provides a rationale for the use of administrative boundaries (city, county, state) to define the term local, the use of which boundaries can often otherwise seem arbitrary. It also explains why these boundaries may change depending on the context. For example, legal rights to specified sources or quantities of water are managed primarily at the state level, while water treatment is often managed by local utilities. True cost accounting may not always conclude that local is better. One trade-off of increasing local food production could be increased local traffic from consumers driving to farms and farmers driving into the city for farmers markets and to sell to restaurants and other retail and wholesale outlets.

Stakeholders tended to believe that reducing consumption of water and energy from outside the region was a desirable goal for metropolitan Seattle. This reflected a widely shared value of social responsibility, which was translated into wanting to localize some of the externalities of food production (e.g., water use and energy consumption in other locations) instead of allowing them to burden to other communities. Additionally, some stakeholders pointed out that farmland provides important social, cultural, and environmental services within the region, such as carbon storage and flood control.

Producers' local food considerations:

Farm management decisions must be site specific. Producers' values and the political, social, environmental, and economic landscape in which they are operating influence their production and management decisions. These fundamental decisions are affected by, or affect how, FEW resources are utilized locally and how those resources flow across regions. For instance, farm management decisions are site specific and producers vary in their approaches to manure management, dealing with mud in the winter months, rotational grazing, stream bank protection, pollinator habitat preservation, pesticide use, and more such practices.

Farming in Washington is tied to rich cultural traditions. Some farms have been in a family for over five generations. King County also has many immigrant farmers for whom agriculture is both a link to their country of origin and to their present local community. For these and other producers, staying in business is important economically as well as socially and culturally. Farming practices directly affect how FEW resources are utilized locally and how those resources flow across regions.

Consumer demand plays a role in shaping production practices. Success in agriculture depends on finding your niche and building an actionable business plan. In the past decade, consumer demand for organic products and the higher market value of organic produce have led many producers in the region to pursue organic certification. Some farmers look at their annual sales and make adjustments to what they will grow based on that information. For example, the manager of a farmers market observed that many producers are pursuing a business model with a roughly balanced combination of restaurant sales, wholesale, and farmers market sales.

Producers are concerned about a lack of access to food packing, processing, and storage facilities. Some stakeholders noted that lack of access to processing facilities may be less of a barrier than it is commonly thought. Instead, more significant barriers facing producers center on a lack of time and relevant skill sets to add value to raw products. While processing facilities may be perceived as less of a barrier, infrastructure for moving food was a clear challenge. Stakeholders identified the lack of funding for railway and road maintenance as a challenge for producers in

rural parts of the state who could otherwise perhaps participate in locally-produced food markets.

The cost of land in western Washington is high. Several stakeholders asserted that King County land prices have become too high, creating steep entry costs for new farmers and profitability issues for existing farmers who may have traditionally grown lower-value crops. Many producers lease land on short-term leases and cannot secure capital to make long terms investments in their farmland for improvements, such as efficient irrigation systems. One stakeholder noted that this is exacerbated by the fact that it is difficult for counties to support agriculture at the policy level because it does not generate as much money from property taxes as other land uses.

Labor and economic concerns affect agricultural practices. A number of factors currently place limits on labor availability including: (1) a labor shortage due to immigration restrictions on out-of-state seasonal agricultural workers; (2) the solicitation and retention of qualified employees who can offer specialized agricultural labor; (3) the cost of living, which in western Washington is high, therefore, paying a living wage that will attract and retain employees means paying more than minimum wage; and, (4) new federal and county health regulations that require producers to train and certify employees.

Consumers' local food considerations:

Consumers' relationship with food is changing. Stakeholders observed a generational trend toward consumers purchasing more prepared foods and less fresh fruits, vegetables, and raw ingredients. These, and other demographic trends, have become apparent when comparing farmers market sales in different parts of Seattle. For example, stakeholders noted a tendency for older consumers to value organic, fresh produce while younger consumers seem more likely to shop at farmers markets for the social experience and to buy prepared foods.

Seattle is perceived to be a national leader in the local food movement. Farm-to-table dining is popular, and many shoppers are interested in obtaining local products. Yet, at the same time, stakeholders observed that Seattle consumers have come to expect access to all foods year-round. The concept of eating seasonally is perceived to be too limiting by the vast majority consumers. Stakeholders' opinions varied widely on whether marketing campaigns for local food work; some believed that promoting local products was a key component of supporting the regional local economy, while others felt that marketing campaigns do very little to influence consumer behavior.

Access to high quality, nutritious, affordable food is in high demand. In any city with a diverse urban population, discussions about food policy are critically important. Stakeholders expressed enthusiastic support for the Fresh Bucks program, which matches food stamp dollars at area farmers markets. There is recognition that ultimately the price of food and access to purchasing options determines most of the Seattle population's food purchasing decisions.

Conclusions and Implications

It is crucial that the role and impact of food, energy, and water (FEW) management decisions be thoroughly understood in relation to the cultural, economic, political, and environmental context of the region. The interviews analyzed in this study offered insight into the factors that influence decisions about FEW systems use and management, and of emerging concerns, conflicts, and policies in western Washington.

In general, this study revealed a widespread perception that farmers want to be good stewards of the land and thus may be amenable to changes to policies or practices that promote a sustainable FEW environment. This sense of good stewardship partly stems from a long and rich culture of farming in Washington and a solid level of institutional support, such as farmland preservation programs and land trusts, to protect and help farmers as urbanization continues. This strong and supported farming culture has in part facilitated the rise of a robust farmers market culture and strong consumer interest and awareness in organically and sustainably produced food products in the Pacific Northwest.

However, the urban and rural relationships to farming, and thus how we manage our FEW resources, are rapidly changing. Higher land prices and changing land use policies are significantly impacting land tenure patterns and opportunities, which, in turn, shape local food, energy, and water use. There are currently more potential farmers in the area than there is available land for production, which means new entry into the farming business or current expansion can be limited by the inability to find sufficient, high-quality acreage for sale in the area where a farmer wants to buy. The changing value of farmland also means that producers are feeling increasingly pressured to switch from a few traditional crops that are well suited to the PNW to a wide variety of fresh produce and animal products that consumers are increasingly demanding from local food markets. Any policies or behaviors that shift the allocation of where food is produced or what is sold in local markets alter the allocation and flows of energy and water across regions and, particularly for crops not well-suited to the PNW climate, may worsen FEW resource conflicts despite being economically beneficial for producers.

Shifts in consumer preferences may significantly alter not just the types of food that are produced but also alter the embedded energy and water costs associated with food production, processing, transportation, and consumption. In general, interviewees suggested that modern urban consumers were perceived to have, or choose to spend, less time cooking at home than they did in past decades. Thus, there are expanding opportunities for producing prepared and packaged foods locally, but this may lead to noteworthy increases in local water and energy use. Interviewees noted that there are currently significant economic challenges for midsize producers and those not immediately adjacent to urban areas because of high costs associated with moving relatively small volumes of food to

processing plants or markets due to limited access to high-quality infrastructure and transportation options. Current options available are rather energy intensive.

Increasing land values, changing consumer demands, and gaps in local infrastructure can compound problems regional farmers already experience while managing farms and marketing products. For instance, being able to scale up a farm depends not only on the cost of land, but also requires potential buyers to have an in-depth understanding of lending options and how to craft a niche business plan. Meanwhile, existing tax structures do not necessarily reward food production. A shorter growing season and high labor costs in Washington necessarily mean that production is more expensive than other regions of the US and the world. Often, individuals with the resources to own farmland in the greater Seattle area elect to use their land for horses or forage rather than for cultivating food crops. Opting out of the local food market may alleviate some of the growing local demands for energy and water, but reinforces the need for food imports and the associated trade-off of increased energy and water costs that support food trading and importing.

While there are many challenges to managing FEW resources for urban local food markets, the strong traditions, expert knowledge, and cultural heritage associated with farming in Washington State may be the key to ensuring FEW resources are used efficiently in the future. With strong political will and consumer support, agricultural producers and the natural resource managers who work closely with them are in a unique place to recognize and address FEW challenges. Continuing to provide farmers with incentives to implement best management practices, opportunities to further their entrepreneurial education, and increasing the number and accessibility of local food processing facilities could increase the quantity of food that is produced and consumed locally in the Seattle area. This increased near-urban production would also minimize the impact on broader, regional water and energy resources (although perhaps increase the impacts locally, within the city). Considering FEW system interactions and feedbacks holistically is vitally important in conversations about the future of food production and consumption in Washington State. Stakeholders engaged in the regional food system are collectively working toward improved interagency coordination to set goals for agriculture in the region and to address institutional barriers to sustainable management of interlinked FEW resources.

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