BIOAg Final Grant Report: Agroecological Assessment of Farming in the Rural-Urban Interface: Building Resilient Regional Food Systems

Principal Investigator

- Marcia Ostrom, Associate Professor, WSU School of the Environment and CSANR

Co-Principal Investigators

- Lynne Carpenter-Boggs, Associate Professor, Dept. of Crop and Soil Sciences, WSU
- Jessica Goldberger, Associate Professor, Agricultural and Food Systems, Dept. of Crop and Soil Sciences, WSU
- Paul Thiers, Associate Professor, Political Science, WSU Vancouver
- M. Jahi Chappell, Ph.D., Adjunct Faculty, School of the Environment, WSU Vancouver
- Judith Wait, Doctoral student, Environmental & Natural Resource Science (ENRS)

Cooperators:

WSU Small Farms Team; WSU Clark County Extension; Clark County Food System Council; Denise Smee, Clark Conservation District Manager; Ann Foster, Salmon Creek Farmers' Market manager and Clark County Food System Council Secretary; Heather Tischbein; Northwest Cooperative Development Center; Farmer participants, including Jim and Diane Hunter; Valerie Alexander, Friends of Clark County board member; and others.

Key words:

Agroecology, farm assessment, innovation, local food, participatory research, regional food systems, resilience, rural-urban interface, sustainable agriculture, urbanization

Abstract

Farmland in urban-influenced regions produces the majority of vegetables and fruits grown in the U.S., yet rural-urban interface (RUI) farms are threatened by development pressure, climate change, economic conditions, and infrastructure loss (American Farmland Trust, 2007). Developing innovative marketing relationships and strategic policy alliances with urban consumers can potentially enhance RUI farm viability. Community-led food system initiatives, including multi-stakeholder food policy councils and alternative food distribution networks, seek to strengthen such regional consumer-farmer linkages. Viable RUI farms can increase local food production and access, enhance long-term food security, contribute to local economic development, and provide a wide range of ecosystem services. Clark County, with the sprawling city of Vancouver, offers a unique opportunity to investigate RUI food system resilience at the farm level. This under-studied region hosts more than 60 direct market farms.

We proposed to develop and pilot an on-farm sustainability assessment tool that includes indicators for social, environmental, agronomic and economic sustainability through participatory field research with 20 direct market farms. By documenting the usage of BIOAg practices, we highlight areas of farm vulnerability, and identify areas for improvement. The tool will be evaluated and made available for use in other regions. Our project addresses BIOAg priority areas of "social and economic dimensions" as well as the eligible topic areas of "innovation and diversification to increase the resiliency and sustainability of farming and food systems" and "assessment of the environmental, economic, and/or social sustainability of agriculture and food systems that provide direction for needed improvements."

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Grant Project Description

To advance regional food system goals, this project investigated the challenges faced by rural-urban interface (RUI) farms as well as the contributions they make toward agroecological sustainability and food system resilience. The Clark County Food System Council endeavors to retain and increase local food production and sourcing in a region with significant food insecurity and development pressure (FSC, 2012, 2013). As such, research-based guidance for addressing the specific vulnerabilities of local agricultural production is needed. The interdisciplinary research team and advisors helped develop, implement, and evaluate a user-friendly agroecological assessment. Our unique focus on conducting participatory research with direct market RUI farmers was designed to address critical gaps in knowledge and inform policy. In 2012, there were seven Farmers' Markets and 20 community supported agriculture (CSA) operations in Clark County.

This project had the following objectives:

Objective One: To develop an agroecological farm assessment tool for direct market farms that uses indicators of agronomic, social, environmental, and economic sustainability and resilience;

Objective Two: To pilot test the assessment tool with 20 rural-urban interface (RUI) direct market farms;

Objective Three: To analyze results to document the key contributions of these farms toward agroecological sustainability and regional food system resilience and identify areas for improvement;

Objective Four: To evaluate and share the tool and assessment results with other practitioners, partners, and stakeholders.

This project investigated the following **research questions**:

- What are the current and potential areas of vulnerability for RUI food producing farms?
- What will be needed to retain and enhance RUI food production capacity?
- What are useful indicators of environmental, economic, and social resilience for RUI food producing farms and how can these indicators be systematically assessed in Clark County and similar areas?

Resilience in this BIOAg project refers to the capacity to grow food for local consumption over the long-term, whereby farmers implement adaptive strategies to overcome challenges and complexity.

Outputs

- **Work Completed:**

All four Stages of the project are complete, as detailed below. Plans for continued data analysis and dissemination are also in place.

  - **Stage One: Establish research team, advisory group, project management.**

We established a core group of stakeholder-advisors including farmers and representatives from conservation, marketing, retail, real estate, non-profits, and Extension. We also conferred with a multidisciplinary group of advisors including economists, environmental scientists, soil scientists, and entomologists. We collaborated with two emerging community organizations focused on food equity, and received support from the Northwest Cooperative Development Center (NWCDC).

Contextual data on food farming in Clark County was compiled from multiple sources, including agency farm lists, web-searches, and online County parcel information. Farm data was also collected through participant observation and networking at farmer-focused and food system events (farm tours, farmers' markets, community partners' meetings, and conferences). A farm parcel list was compiled that includes 100 farms using one or more direct-to-consumer market channels (farmers' markets, farm stands, U-pick, CSA, and/or farm events). Based on farm characteristics identified in this master list, 23 farmer partners were selected to pilot the implementation of the Farm Resilience Assessment Tool (FRAT).

- **Stage Two: Engage scientists and farmers in advising on development, implementation and evaluation of the assessment tool.**

The resulting Farm Resilience Assessment Tool (FRAT) is comprised of a set of indicators of agronomic, social, environmental, and economic resilience. The process of FRAT development exemplifies an iterative process of adaptive project management.

Initial development of the FRAT was informed by other "tools" and models, as were the scoring criteria for resilience indicators. We compared the "public goods" assessment tool (Gerrard et al., 2012), the behavior-based resilience indicator framework (Cabell & Oelosfse, 2012), and the characteristics of farm resilience (Milestad & Darnhofer, 2003), in order to correlate adaptive strategies hypothesized to be important to farm resilience. The agroecological scoring criteria chosen were additionally informed by Gliessman's agroecology textbook (Gliessman, 2015), Guthman's dissertation research methods (see the Appendix of Guthman, 2014), and other analyses of agroecological resilience (Altieri, Nicholls, Henao, & Lana, 2015; Nicholls et al., 2004).

Ongoing engagement with stakeholder-advisors for the FRAT helped prioritize the indicators to include on-farm trials, which took place at two urban agriculture sites over summer, 2014. We tested methods for assessing soil management strategies and biodiversity. A final draft of the semi-structured interview questions was tested with two advisors in December, 2014 and January 2015. Revisions were incorporated and the FRAT scoring framework was refined. Initial summary findings were shared with research participants and project advisors in order to solicit their feedback.

Data collection for the FRAT involved on-farm interviews, farm tours, and field observations. For the final sample of farms participating in the Farm Resilience Assessment, information that was compiled prior to interviews, from multiple sources, was cross checked with the farmers during interviews. After the in-depth semi-structured interviews were complete, and data compiled, the FRAT scoring system was refined based on preliminary analyses. Farmers who participated in the roundtable meeting provided additional information and contributed their evaluation.

- **Stage Three: Conduct on-farm assessments, process and analyze data, review results with farmer participants.**

On-farm assessments featuring semi-structured, in-depth interviews and site observations with farmers were conducted. The final sample of 23 farms was selected from an initial list of all direct market farms in the study region that raised vegetables and/or fruits, as part or all of their farm operations. FRAT farms varied on many other attributes—such as management practices, size in terms of land and gross sales, operator age, land tenure, time in farming, and the number and diversity of market outlets used. Data was compiled into the FRAT spreadsheets, helping to facilitate farm characterization, resilience indicator scoring, and analysis.

Initial results were shared at the monthly meeting of the multi-stakeholder Food System Council (including farmers), and with farmers and other advisors. The farmer roundtable was multifunctional in that more information was gathered, some results were confirmed or expanded upon, and it led to some FRAT scoring criteria modifications.

The most notable finding that emerged from preliminary data analysis was the high level of commitment to the pursuit of *sustainability* practices such as water conservation, soil enhancement, and biologically-based pest management. The results also confirmed that farmers pursue a diverse range of economic strategies. Many farmers in the study were interested in more opportunities to aggregate their products to serve markets such as restaurants or institutions. Some were already engaged in informal cooperation and product aggregation. Most saw the need for greater farmer-to-farmer networking. These topics will be investigated in greater depth as we continue to analyze this data over the next year.

- **Stage Four: Report and Disseminate Findings**

We completed the final research technical report, attached to this grant report.* Graduate student Judith Wait will be further analyzing and utilizing the data gathered in this project for her dissertation. As such, this report will be reviewed by co-PIs, commensurate with future dissemination plans to submit a summary article to the Journal of Agriculture, Food Systems, and Community Development (JAFSCD). In addition, we will produce a poster and presentation for future conferences.

- ## Publications, Handouts, Other Text & Web Products:

Over the course of the grant project, we periodically distributed research project summary updates via email, through individual communications, and at organizational forums (meetings where we were invited to give presentations). For each meeting, we produced a handout summarizing the research, the FRAT framework, and results pertinent to the timing and audience. A summary report from the farmer roundtable was produced, as well as a contact list they requested.

In addition, the following documents were distributed and referenced by stakeholders: 1) "Economic Significance of Food and Farming in Clark County," a compilation of selected data on the agricultural sector, primarily from the 2012 Census of Agriculture; 2) "Food Production Agriculture & Farmland in Clark County: Notes on the Benefits of Farmland Protection." The Clark County WSU Extension horticulturalist handed out both documents for a farm tour he co-led for policy-makers and agricultural-food system leaders.

- ## Outreach & Education Activities

Communicating with individual farmers and cooperators was ongoing throughout the project, including networking at Farmers' Markets, farm visits, educational workshops, and conferences—such as Tilth Producers of Washington (2014) and Washington State Farmers Market Association (2013-14). Outreach led to meeting more farmers and expanding the farm parcel list. We talked with farmers about their local food system participation. During summer 2015, we coordinated five days of farm tours and interviews with diverse stakeholders. The sessions were video-recorded by two WSU communications undergraduates.

To address farmer identified needs, as opportunities arose, we worked with community partners to develop grant proposals for participatory research, including market risk assessment, community food system assessment, and outreach to include small socially disadvantaged producers (see also Funding, and Impacts).

Several outreach and education activities were co-organized with community partners. NWCDC's SSDP grant funding helped support the following activities:

1. Value Added Producer Grant (VAPG) workshop (presentation by Greg York, Rural Development, based on our invitation, February 18, 2015);
2. Matt LeRoux of Cornell Cooperative Extension visited Clark County (February 24-25, 2015). For the occasion, we organized an informal gathering for food system leaders, farm tours, and a workshop on the Market Channel Assessment Tool (MCAT). [i]
3. A series of capacity-building sessions were co-facilitated with a subgroup of Southwest Washington's network of women farmers and supporters.
4. In order to test Market Channel Assessment Tool (MCAT) implementation, tracking forms and instructions were modified and then translated into Spanish. The pilot farm uses multiple types of market channels. Data was processed through the MCAT spreadsheet (M. LeRoux & Schmit, 2011), and preliminary results were presented to the farmer.
5. Project outreach was conducted at a harvest festival hosted by a participating farm. .
6. Outreach for scholarships for rural producers to attend the Cultivating Cooperative Roots Conference sponsored by NWCDC, scheduled right after the 2016 Spokane Ag Expo.

In addition, presentations on this BIOAg research, as well as on the MCAT, were delivered at the Small Farms Team retreat in March, 2015. Clark County Extension and several community partners co-hosted the VAPG and MCAT workshops at the Heritage Farm in Vancouver.

Impacts

- **Short-term Impacts (Knowledge gained and shared)**

This participatory research was initiated in response to Clark County food system stakeholder goals of preventing further loss of farms and food production infrastructure capacity. Co-PI Judith Wait has regularly attended monthly Clark County Food System Council meetings to keep cooperators and interested stakeholders mutually informed about the progress of the research; share initial findings from secondary data collection such as information from the Census of Agriculture; and communicate about relevant policy implications. She has also maintained ongoing communication with project advisors and farmer participants, and shared summary results to get their feedback.

Following our research on the irrigation water access problem, one cooperator helped find a favorable determination for small farm operations lacking a certified water right. The current Washington Department of Ecology (DOE) position is that farms using less than 5,000 gallons per day fall under the Exemption for industrial uses.

- **Intermediate-term impacts (current & expected change in behaviors)**

Some project impacts observed during the 2015 grant period followed producer workshops, educational farm tours for policy makers, and informational presentations to stakeholders.

For example, Clark County producers who attended a workshop on the Market Channel Assessment Tool (MCAT) became interested in conducting assessments on their farms. One farm piloted MCAT. Lessons learned include the challenge of tracking multiple tasks and laborers working to fulfil several market outlets and manage multiple crops in any given day during peak season amid a heat wave. Behavior changes for the next season might include focusing on the more profitable market outlets.

After the Value Added Producer Grants (VAPG) workshop in 2015, five producers initially intended to develop proposals for value-added projects. However, the application process is still too cumbersome for some producers. The Clark County Extension director, along with County economic development leaders, presented a proposal to the County Board of Commissioners to incorporate farm viability topics, such as MCAT and VAPG, into their work plan to promote economic development and job creation in the agriculture and food sectors.[ii] For 2016, the VAPG workshop will be sponsored by Clark County Extension and Rural Development. In addition, Extension has offered additional value added technical assistance in the interim.

FRAT research confirmed the need for more farmer networking opportunities, so the roundtable offered one venue. Farmers learned about other farmers' approaches to some common problems, and identified ways farmers could work together to overcome hurdles. They made future plans to learn more from one another. Examples include participating in soil management classes offered by a soil scientist farmer, and sharing Organic orchard management strategies. Farmers appreciated inclusion in farm resilience research, and that researchers are interested in helping to identify (and pursue) solutions.

- **Long-term (potential change in economic/environmental/social situations)**

The long-term goal of this project is to inform resource allocation and land use decisions that affect both immediate and long term farm viability. Our objectives are to document the problems facing small and mid-sized commercial food producers; to help ensure that farmer needs and aspirations are addressed in local food system development strategies; and to support farmland protection for the long-term. The research questions align with the Food System Council (2013) and Clark Conservation District (CCD) strategic plan[iii] goals to enhance the sustainability and capacity of local food production agriculture. Initial data gathering and informational presentations were utilized by agricultural-food systems stakeholders for input to the County's 2016 Comprehensive Growth Plan update, which plans for 20 years into the future and is updated every 10 years. The Food System Council and associated leaders request our ongoing participation. Furthermore, this project identifies future research needed to inform the implementation of solutions and foster collaboration across technical, educational, economic, and policy sectors.

Additional Funding Applied For / Secured

- **Most Recent Grant Proposals**

<u>Rejected</u>

1. Ostrom, M. and J. Wait. *Participatory Evaluation and Education on the Risks and Benefits of Alternative Markets with Diversified Vegetable Producers*. Proposal submitted Nov. 17, 2014, to the Extension Risk Management Education's Western Center (WSU) $49,962.

<u>Secured by Graduate Student:</u>

1. Wait, Judith. *Resilience of Small-Scale Food Farming in Urbanizing Regions.* Anne and Russ Fuller Fellowship for Interdisciplinary Research/Scholarship award of $4,000 for 2015. Second year renewal application pending for 2016.
2. Northwest Cooperative Development Center (NWCDC) was awarded a 2015 grant to support outreach for "Cooperative Education And Business Basics For Small Socially Disadvantaged [rural] Producers." that included funding for collaborating with our community partners in SW Washington.

Secured by PI:

3. Peterson, H.; Feenstra, G; Hardesty, S; Ostrom, M; Tanaka, K, "Impacts of Values-Based Supply Chains on Small and Medium-Sized Farms," proposal submitted to USDA AFRI NIFA through Kansas State University (2014-2016) $500,000.
4. Moulton, C, Collins, D., Ostrom, M., and Jose Garcia-Pabon. "Farm Business Management Educational Program for Washington State," USDA Risk Management Agency, RME Program (2013-2014), $96,613, included funding, curriculum, and coordination for Cultivating Success farmer educational program in Clark County.

- **Future Funding Possibilities**

Program development with producers, community partners, advisors, economists, Clark County Extension agents, and the Conservation District continues to be a possibility, but requires a high capacity applicant.

1. USDA NIFA Community Food Projects Competitive Grants Program: Clark County collaborators identified the need for an overall agricultural-food system assessment and an inclusive process featuring community forums.
2. Western SARE: We have established partnerships with primary producer-cooperators and a professional agricultural advisor in order to consider a future project.
3. The Conservation Innovation Grants (CIG): Funded through Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) is applicable to producer and agency biodiversity improvement goals and project effectiveness monitoring

Graduate student funded

The budget supported Judith Wait's Research Assistant (RA) position, October 2013 through May, 2015, as well as hourly work in the summers of 2014 and 2015. Additional funding from other sources helped with farmer honoraria and expenses.

Recommendations for Future Research

This BIOAg project contributed to research recommended by Kate Clancy (2013) and the National Research Council (2010) in the following ways: We collected empirical data that will contribute to the national understanding of the requirements for viable local farming systems and we pioneered a model for place-based, participatory on-farm research that can be applied to other regions. This resilience-focused "transdisciplinary food systems research" (Clancy, 2013; National Research Council, 2010) similarly encountered the urgent need for better farmland preservation, a policy context considered adverse by farmers and their supporters, and calls for (re)building adequate processing and market infrastructure. More support is needed to meet multi-stakeholder goals to improve food security based on locally grown food. Across multiple disciplines, participatory research, in-depth agronomic technical assistance, and farmer support networks could be inter-linked to form a greatly needed social infrastructure model. In addition, guidance could be adopted from models in a watershed in Oregon (Flitcroft, Dedrick, Smith, Thieman, & Bolte, 2009), and a Virginia-based land grant university (Kimmel, Hull, Stephenson, Robertson, & Cowgill, 2012).

This project was a useful first step in our regional context and is expected to continue to help stimulate the pursuit of solutions by farmers, agencies, relevant stakeholders, and interested citizens. However, based on the lack of reliable data on the agricultural sector, and food production in particular, more in-depth research recommended by economists would include a farm-by-farm “census” of all farming operations. Such research could tie in with the crop surveys done periodically by the Conservation District for the Washington Dept. of Agriculture.

In addition, future research and education funding is recommended to implement the Market Channel Assessment Tool (MCAT) in Clark County. MCAT is a risk management strategy for farms to evaluate the effectiveness of their market outlets in terms of labor, expenses, and income associated with activities from harvest to sales in order to optimize decision-making (M. N. LeRoux, Schmit, Roth, & Streeter, 2009).

The FRAT results add farmers’ recommendations and specificity to future project considerations. Recently, a list of thirteen project ideas from seven agri-food leaders was compiled by Leadership Clark County. A needs assessment, community forum, and planning report were on the list. Among the top challenges faced by farmers are access to affordable farmland, lack of public support, lack of market access. The FRAT results confirmed these findings. In the context of this BIOAg grant, we looked for funding to implement such recommendations for associated projects with community partners.

Research on former farms is an important area for future research on farm resilience. A greater understanding of why farms fail could allow more strategic prioritization of assistance. At least eight farms targeted for participation in this research ceased or greatly diminished operations in the last several years. New farm operations have started, but five retail-to-consumer marketing outlets that carried local produce are no longer operating, including the Uptown Urban Farmers’ Market. Eleven farms interviewed for this project have stopped participation in one or more Farmers’ Markets over their history.

With farms and farmers at the center of this research to identify farm vulnerabilities, we have documented strategies important for retention and enhancement of food production capacity. Ideally such strategies could be used to inform policy and incorporated into integrated education, Extension programs, and a long-term research agenda. Integrated programs could contribute to market strategy improvements for farmers and market channels. Results of this BIOAg grant could be included in a stakeholder-recommended comprehensive food system assessment and agricultural strategic plan.

*Please see also the attached Technical Report mentioned in Stage 4 above.

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[i] LeRoux, Matthew; unpublished reports; personal communications in person and emails, Nov. 2014-Feb. 2015

ii The slides for the presentation are available at http://www.clark.wa.gov/thegrid/documents/WSUeditedver3.pdf and the recorded session is found at http://clark.wa.gov/thegrid/052715CMB.MP3

[iii] http://www.clarkcd.org/publication/

Agroecological Assessment of Farming in the Rural-Urban Interface: Building Resilient Regional Food Systems

CSANR BIOAg Grant Project Technical Report

Abstract

This document comprises the technical report for the BIOAg grant project, Agroecological Assessment of Farming in the Rural-Urban Interface: Building Resilient Regional Food Systems.[1] This graduate student project investigated rural-urban interface (RUI) farms in rapidly urbanizing Clark County, an area with significant food insecurity. We proposed to develop and pilot an on-farm agroecological assessment tool to better understand what will be needed to retain and enhance local food production capacity for the long term. The resulting tool—the Farm Resilience Assessment Tool (FRAT)—was designed to summarize farm characteristics for 29 indicators in the agronomic, economic, environmental, and social realms. The FRAT indicators were selected to answer research questions about the strengths and vulnerabilities of the participating farms.[2] We identified more than 100 direct market farms in this county that used one or more market outlets, such as Farmers Markets, Community Supported Agriculture (CSA), U-pick, farm stands, and/or agri-tourism. Of these direct-market farms, 23 vegetable and/or fruit producers were selected to participate in our pilot study. Initial results from implementing the FRAT with these farms identified crop diversity, conservation practices, informal farmer networking, and marketing mix, as strengths. The vulnerabilities of the selected farms appeared to include a lack of access to agroecological information, a lack of public policy support, and a need for more reliable and profitable market outlets. Initial evaluations of the FRAT as a pilot tool suggest it could be streamlined to be more portable and less time-intensive. Upon further analysis of the data collected for this project, additional recommendations for the next version will be forthcoming.

[1] Ostrom, M. (PI), co-PIs: Wait, J., Carpenter-Boggs, L., Goldberger, J., Thiers, P., & Chappell, M.J. (2013-2015), *Agroecological Assessment of Farming in the Rural-Urban Interface*, funded by a WSU Center for Sustaining Agriculture and Natural Resources (CSANR), BIOAg grant.

[2] Further analysis of the data generated for this project will continue as part of the dissertation project of Ph.D. candidate co-PI (Judith Wait).

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I. Introduction

The purpose of this BIOAg project was to develop an agroecological assessment tool for systematically evaluating urban food system resilience at the farm level, pilot the tool with a diverse set of direct market farms, and consider the applicability of the tool outputs for prioritizing farm support and agrifood system interventions. This document describes the process of developing the Farm Resilience Assessment Tool (FRAT), which involved reviewing other approaches to evaluating complex social-ecological systems. Secondary data was compiled to facilitate greater understanding of the agrifood system context in rapidly urbanizing Clark County. The FRAT uses indicators of agronomic, economic, environmental, and social resilience to systematically assess farm operations. The primary data collected and compiled for the FRAT analysis was based on farmer interviews and site assessments.

Based on implementation of the FRAT, as applied to a diverse selection of 23 pilot farms, this document also presents the summary outputs of the FRAT (version 1). To help illuminate the challenges and solutions for RUI farm resilience, we piloted the FRAT using a set of 29 indicators of agronomic, environmental, economic, and social resilience with 23 food-producing farms in Clark County that use direct-to-consumer market channels. Outputs are based on scoring for each of the 29 indicators, and presented for all 23 farms in aggregate.[3] In keeping with our four-realm conceptual framework, indicators are presented by the Agronomic, Market-economic, Environmental, and Social realms for all the farms.

The FRAT was designed to address the following research questions: 1) What are the current and potential areas of vulnerability for RUI food producing farms; and 2) What will be needed to retain and enhance food production capacity for the long term? The FRAT comprised the primary research instrument, yielding key indicator scores to inform further analysis. Preliminary results from piloting version one of the FRAT indicate overall moderate levels of resilience with room for improvement in all the realms, and particularly a need for marketing, economic, and infrastructure support. With further in-depth analysis and additional farmer feedback, tools such as this could help guide future farmer support efforts.

This report first provides a background on conceptualizing agroecology, urban agriculture, local food systems, and resilient farming; and highlights key assessment models reviewed to inform the development of the FRAT. The background on Clark County agriculture provides the context for this pilot study of an urbanizing region. Research methods are described, followed by a detailed report on the results of the FRAT Analysis. The report ends with a brief evaluation of the usefulness of the FRAT and a concluding summary. The Appendix provides additional details on FRAT indicator scoring criteria.

[3] We present aggregated scoring for indicators in this document. Individual farm results are not presented here per our commitment to the confidentiality of the farm-specific data with farmer participants.

II. Approaches to Conceptualizing the Resilience of Urban Area Agriculture

This section briefly considers key concepts from relevant literature to establish a background and theoretical context for (A) this project's sustainable agriculture focus, including: 1) agroecology, 2) urban area agriculture, and 3) localized food systems. We also highlight selected characteristics of (B) farm resilience based on key literature and (C) summarize a range of assessment approaches that informed the development of the assessment tool for this project.

A) Sustainability of Agriculture

The sustainability of the agrifood system is threatened by rapid changes in socio-economic and environmental conditions all over the world, spurring a wide array of responses aimed at system mitigations, reforms, transition, and/or transformation (De Schutter, 2010; Holt Gimenez & Shattuck, 2011; IAASTD, 2009). A broad spectrum of alternative food system initiatives and organizations has emerged to support food production at many scales and the sustainable agriculture movement goals encompassing social, environmental, cultural, and economic justice (Henderson, 2000; IAASTD, 2009). Food and farming systems based on *agroecology* have been recognized as means to address social and environmental justice issues in the context of *food insecurity* (De Schutter, 2010, 2014). In contrast to the conventional production-dominated paradigms of agricultural development, an emerging "new paradigm" considers food a basic human right, whereby goals of sustainability yield a diversity of interdependent solutions that enhance food and farm system resilience (De Schutter, 2014). Proposed solutions include 1) agroecology, 2) strengthening urban area agriculture, and 3) relocalizing food systems.

1) Agroecology

Agroecological approaches are designed to enhance economic, environmental and social sustainability goals (Buttel, 2007). Application of agroecological principles can improve agricultural sustainability by providing multiple benefits such as increasing soil organic matter and crop yield, reducing pollution, and improving household food security (IAASTD, 2009). *Agroecology* as a concept encompasses a set of agricultural practices, the integrated scientific disciplines informing the practices, and a social movement (Wezel, 2009). An agroecological framework acknowledges the inherent complexity of food and farming systems and addresses the need for bridge-building across multiple levels of analysis and multiple disciplines (Francis et al., 2003). For example, in case studies involving farmers, researchers documented that agroecological practices—including cover-cropping, crop rotation, and soil organic matter maintenance—contribute to the ecological diversity of agroecosystems (Gliessman, 2014). Agroecological practices are considered essential for boosting farm resilience in the face of climate change, and "scaling up" can occur through diffusion of such diversified farming approaches through farmer learning networks (Altieri, Nicholls, Henao, & Lana, 2015; Kremen, Iles, & Bacon, 2012). Agroecology is considered a "transdisciplinary, participatory and action-oriented approach" where farmers' knowledge is important (Méndez, Bacon, & Cohen, 2013).

The agroecosystem concept can be applied at a field, farm, landscape, regional, or food system scale. At the farm level, the *agroecosystem*, or "site of agricultural production" includes farm inputs, outputs, and their complex interactions (Gliessman, 2014: 21). The farm encompasses the farmer, farm assets, markets, location, interactions, and social contexts (elements of a "farming system" after Darnhofer, Gibbon, & Dedieu, 2012). Farming systems are "complex adaptive systems" requiring a wide array of management strategies (Darnhofer, 2014: 474). The basic defining characteristics of resilient social-ecological systems—strategies that build resilience in complex adaptive systems—include cultivating diversity and redundancy, learning from experimentation and feedback, understanding ecological systems, and participating in social systems (Quinlan, Berbés-Blázquez, Haider, & Peterson, 2015).

2) Urban Area Agriculture

Urbanizing regions experiencing development pressures are increasingly complex to define, study, and plan for, as the boundaries between *urban* and *rural* get blurred and rapid transitions are underway (Russo, Tomaselli, & Pappalardo, 2014). While agriculture in urban regions significantly contributes to food security and livelihoods, the competition for scarce resources intensifies as urban populations continue to increase (Gundel, 2006). Farmland in urban-influenced regions produces the majority of vegetables, fruit, nuts, and dairy grown in the United States, but such farms are "in the path of development" (American Farmland Trust, 2007).

Urban area agriculture can be broadly defined as agriculture that is "integrated into the urban economic and ecological system"[i] (de Zeeuw, 2010), and therefore includes farms marketing food in the city, farms located in urban neighborhoods, and producers beyond the city and urban growth boundaries. In the informative literature, these regions are variously referred to as *peri-urban* (Torreggiani, Dall'Ara, & Tassinari, 2012), *rural-urban interface (RUI)* (Jackson-Smith & Sharp, 2008), and *rural-urban fringe* or *exurbia* (Sharp & Clark, 2008). Jackson-Smith & Sharp (2008) define *rural-urban interface* (RUI) counties by their Urban Influence Code or high population growth rate, designated by the USDA Economic Research Service (ERS)[ii]—whereby about half the Counties in the U.S. qualify as RUI (Jackson-Smith & Sharp, 2008).

RUI counties generate more than 75% of nation-wide organic and direct market sales (Jackson-Smith & Sharp, 2008). Research on RUI counties in the U.S. found a positive relationship between the presence of food policy councils (or similar networking organizations), economic support policies, and programs for farmers—and numbers of farms, as well as the optimism of farmers (Sharp, Jackson-Smith, & Smith, 2011). Such *social* support networks, as well as good neighborly relationships with farmers, help to balance private landowner interests with land use policies that protect agricultural capacity (Libby & Sharp, 2003).

A county's agricultural importance (AI) rating is based on total sales, and the market value of products sold per acre, as reported in the 2002 Census of Agriculture (Jackson-Smith & Jensen, 2009). Across Metro AI counties in the U.S., RUI farmers were found to be very diverse in demographics, production systems, and market strategies (Inwood, Clark, Inwood, & Clark, 2013). Having a diversity of farm types and scales is a way agricultural resilience can be promoted (Berardi, Green, & Hammond, 2011). But as the number of farms and amount of farmland continue to decline, the *agricultural importance* (AI) of urbanizing regions is often under-appreciated, even as metropolitan region counties account for a significant proportion of overall farm production and value (Jackson-Smith & Jensen, 2009). Further confounding the allocation of resources to support emerging farming models, the USDA Census of Agriculture falls short in reflecting direct market sector attributes (Hunt & Matteson, 2012), such as over-counting the number of Community Supported Agriculture (CSA) farms (Galt, 2011) and undercounting total direct market sales (Ostrom and Donovan, 2013).

Having a strong network of support for farms is a critical element in defining resilience (Milestad & Darnhofer, 2003) and cultivating the viability of farming, with crucial policy implications for urbanizing regions (Libby & Sharp, 2003; Sharp et al., 2011). Yet farm diversity seems to pose challenges for technical assistance providers, funders, farm supporters, policy advocates, and other stakeholders. There are few, if any, one-size-fits-all solutions. Indeed a full suite of policy-related tools are recommended (Canty, Martinsons, & Kumar, 2012). Policies focused on enhancing farm viability in the RUI—on national, state, regional and county levels—need to be integrated to better support farming and ensure the multiple community benefits of having a strong sustainable agricultural sector (Jackson-Smith & Sharp, 2008).

3) Relocalizing Food Systems

Intending multiple benefits to communities, a wide diversity of efforts to rebuild local food systems have proliferated (Feenstra, 1997; Henderson, 2000; Lovell, 2010). Consumers increasingly want to know where their food comes from, yet knowledge—about farmers, the work, and the diverse farms engaged in production for local and regional markets—is limited (Chase & Grubinger, 2014). In order to promote stronger connections between producers and consumers, several direct-to-consumers marketing and distribution strategies have been pursued (Hinrichs, 2000; Low & Vogel, 2011). Farmers are increasingly interested in alternative production and processing opportunities to help them become profitable in the face of marginal farm economic viability and the rapid loss of productive farmland (Ostrom & Donovan, 2013).

Producer sales through such direct-to-consumer and intermediated regional supply chains (institutions and mid-scale distributors) are increasing for small and mid-size farms, with nearly eight percent of U.S. farms contributing to local and regional food markets (Low et al., 2015: iii). Urban regions offer multiple benefits for farms, but in King County, Washington, for example, the outlook for future farm viability and food system resilience is much less optimistic (Oberholtzer, Clancy, & Esseks, 2010) than might be indicated by the proliferation of Farmers Markets. While access to urban consumers is a key benefit of operating farms near urban markets, there are many challenges—including uncertainties about the future, regulatory burdens, limited access to land and water, and misunderstandings with nearby residents and the general public (Hammond, Green, & Berardi, 2013). These challenges echo farmers' perspectives documented in local Clark County and statewide reports (Ag Preservation Committee, 2009; Office of Farmland Preservation, 2009).

B) Characterizing the Resilience of Farms

To assess the sustainability of farming, a *resilience approach* offers a transdisciplinary integration of socio-economic and *agroecological* considerations (Darnhofer, Fairweather, & Moller, 2010). The application of a resilience framework at the farm level—one that considers the importance of farmers' preferences, goals, abilities and adaptability– is a nascent and needed field of research (Darnhofer, Moller, & Fairweather, 2008). Applying resilience thinking to research (or management) acknowledges the uncertain context of farming, and favors qualitative approaches to increasing the understanding of farming system dynamics (Darnhofer, 2014). The three characteristics that define resilience are: (1) Buffer capacity (understanding natural cycles, diversity and flexibility, and stewardship); (2) Ability to self-organize (independence from external sources for information or inputs, and local market networks); and (3) Capacity for learning and adaptability (learning, and feedback mechanisms) (Milestad & Darnhofer, 2003).

Resilience means having the ability to adapt to, learn from, and recover from disturbances, as well as taking advantage of changing conditions, in order to maintain or recover a desirable state (Berardi et al., 2011). Considering scenarios of rapid change and extreme events (urbanization, energy cost hikes, climate change, and intense weather), farmers identified the following adaptive strategies: reducing externally derived inputs, niche markets, personal commitment to farming, ongoing learning and strategizing, and possessing a wide range of farming business and social skillsets (in farmer focus groups convened by: Hammond et al., 2013). To reduce risks, farmers can build redundancy and maintain adequate resources to solve problems that arise (Berardi et al., 2011).

Resilience in this project refers to the capacity of farms to grow food for local consumption over the long-term, whereby the farmer implements adaptive strategies to overcome challenges and complexity. Farmers may enhance farm resilience by conserving resources; growing a diversity of crops for diverse markets; and sharing information among themselves about different practices (Cabell & Oelosfse, 2012; Milestad & Darnhofer, 2003). For example, farmers responding to dramatic changes in commodity market conditions or drought, amid unpredictable urban encroachment, would demonstrate flexibility and *adaptive capacity* by diversifying the crop mix, installing drip irrigation, and/or targeting urban customers through higher value market channels. Such *adaptive strategies* can serve to maintain family farm viability, even as the farming operation itself is transformed.

C) Developing an Applied Research Approach to Assess Farm Resilience

This project proposed to review a selection of assessment approaches for their utility and relevance in evaluating farming system sustainability. As set out below, we found that we could adapt several elements and principles from other models, but there was no single model suitable for this project. This assessment framework adapts and incorporates the most useful elements from other models in selecting indicators and developing methods for data-collection, analysis, reporting, and stakeholder engagement.

We found that many farm assessment frameworks had basic elements in common, even though they have been applied in different geographical contexts such as Europe or the Global South. These approaches consider multiple realms (environmental, social, and economic) and have several fundamental indicator categories in common, yet are particular to the research objectives and contextual application. Several "agri-environmental" evaluation tools have emerged in the European Union context with the EU's Common Agricultural Policy (Gerrard et al., 2012). Gerrard et al (2012) developed the "public goods" tool to consider the multiple contributions of organic farms across a range of economic, social, and environmental realms in addition to the agricultural production (Gerrard et al., 2012). The "PG tool" has been used by agricultural agents as a time-efficient way to score farms according to key "activities" within each of the areas considered to be public goods—agricultural systems diversity, soil and nutrient management, biodiversity, water management, landscape and heritage, energy and carbon, food security, social capital, animal welfare, and farm business resilience (Gerrard et al., 2012). Pilot tested in the UK on 40 farms using readily available quantitative and qualitative information and a two to four-hour time framework for data collection, farms were scored individually on a scale of one-to-five for each activity. Scores for each activity were then analyzed across farms using average, median, standard deviation, and range. Results were also aggregated for each area and displayed in radial diagrams showing mean, maximum, and minimum scores (Gerrard et al., 2012).

Examining a similar set of parameters in their review of literature comparing conventional and biologically diversified farms around the world, Kremen and Miles (2012) found that *diversified farming systems* support substantially greater ecosystem services (biodiversity, soil quality, carbon sequestration, and water-holding capacity in surface soils, energy-use efficiency, and resistance and resilience to climate change). Most *ecosystem services* are also considered *public goods* (Boyd & Banzhaf, 2007). Kremen and Miles (2012) reviewed numerous case studies, meta-analyses, and quantitative syntheses, and concluded that much more research focused on diversified farming systems is needed in comparison with the relatively abundant research on conventional mono-cropping systems.

An indicator-based approach developed in Mexico and applied to peasant agriculture, MESMIS[iii] is a Framework for Assessing the Sustainability of Natural Resource Management (NRM) Systems (López-Ridaura, Masera, & Astier, 2000). Lopez et al (2002) emphasize the importance of *integrating* economic, environmental, and social sustainability indicators, along with multi-disciplinary processes of selecting the most strategic indicators that can be estimated or measured for aggregation. Key attributes of sustainability frame the assessment indicators including productivity, stability, reliability, resilience, adaptability, equity, and self-reliance (López-Ridaura et al., 2002). In their review of 60 cases of MESMIS implementation over 15 years, primarily in Latin American countries, Astier et al. (2012) suggest a need for long-term funding of such monitoring and engagement for evaluating the sustainability of diversified farming systems and communities. The MESMIS online educational tool can be used to evaluate a range of NRM scenarios, and features a stakeholder participation process integrated with scoring and display components of the tool (Speelman, López-Ridaura, Colomer, Astier, & Masera, 2007). In the MESMIS cases reviewed by Speelman et al (2007), a wide range of data-gathering approaches were used, including direct field monitoring, simulation models, review of literature and weather data, surveys, interviews, and participatory group field visits. Radial diagrams were used to display indicator data for each type of management practice (conventional and modified) as a percentage of an optimal practice. Results were aggregated and subsequently used for spatial or temporal comparisons, as well as scenario testing (Speelman et al., 2007).

Compared to MESMIS, the IDEA[iv] method, applied widely in Europe (especially France), is a more structured and less participatory agricultural sustainability assessment model that uses 49 quantitative indicators to yield indexes in "agri-environmental," economic, and "socio-territorial" dimensions of production systems (Cândido, Nóbrega, Maior, & Figueiredo, 2015). Scores for key farm attributes, chosen from a long list of indicators, are compared to group averages, and displayed in radial graphs on a scale of zero to 30, with the intention of informing stakeholders on the path to more sustainable agriculture (Cândido et al., 2015).

The recently released Self-evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists (SHARP) tool was developed by the Food and Agriculture Organization (FAO) of the United Nations over the last few years and applied in several African countries (Choptiany, Graub, Dixon, & Phillips, 2014). SHARP developers systematically reviewed a wide array of evaluation tools applicable to international development contexts and resilience (Choptiany et al., 2014). They examined a few of the same tools we found, such as the Resilience Alliance (2007a, 2007b) workbooks for scientists and community facilitators, recommended for social-ecological systems evaluation and planning. After reviewing 21 existing assessment models in depth and learning from other tools, the FAO documented the need for a new tool. These developers based their SHARP tool on the behavior-based resilience framework for evaluating agroecosystems of Cabell and Oelosfse (2012) (Choptiany et al., 2014).

The SHARP tool consists of 54 sets of questions associated with the 13 behavior-based indicators of Cabell and Oelosfse (2012). Several questions have "pick lists" of items that are counted up to obtain a score, such as crops grown or organizations in which a farmer might participate (Choptiany et al., 2014). The SHARP tool adds a component for farmers to identify how important they feel a practice is, or how involved they might be in the activity (Choptiany et al., 2014). The highest total score possible is 30, after additional scoring criteria are added based on the farmers' response (Choptiany et al., 2014). SHARP results are shared via radial diagrams (of indicators averaged for aggregation purposes) and bar charts for discussion and tracking; Farmers and supporters can see that a low score for an important indicator suggests a high priority for attention and intervention to improve a critical situation (Choptiany et al., 2014).

In the SHARP tool, indications of resilience are conceptualized both as measurable outcomes, and as an essential ability to adapt (Choptiany et al., 2014). Based on their extensive review of additional (and some of the same) resilience analysis approaches, Quinlan et al (2015) recommend such a hybrid approach combining any *measurement scheme* with resilience *assessment.* MESMIS is not meant to be a *measurement* of sustainability per se, either, whereas the tool enables comparisons of systems across space or time, and qualitative graphics integrate the indicators using a "percentage relative to the optimum" using an "AMOEBA" diagram (López-Ridaura et al., 2000).

A basic premise of *participatory* engagement models is that the indicators are co-developed with stakeholders--whether the tool outcomes are meant to be used for information, discussion, monitoring, and/or resource allocation for interventions (Quinlan et al., 2015). Both the MESMIS (Speelman & Garcia-Barrios, 2010) and SHARP (Choptiany et al., 2014) models incorporate step-wise processes for engaging stakeholders before the portable tool is implemented. Both of these tools consist of a series of questions for farmers to answer, including "pick lists" for farmers to identify practices or other information. Outputs are also reviewed with stakeholders to inform on-farm, community, and institutional investments. Radial diagrams are commonly used in participatory models to display data and share assessment results with farmers (Choptiany et al., 2014; García-Barrios, Speelman, & Pimm, 2008). On such "amoeba" diagrams, average values for participating farms can be plotted for comparisons and discussion (Nicholls et al., 2004).

In an application of the activity-based adaptation index (AAI), qualitative data was collected from several villages within each of two rural regions in Tanzania using a participatory rapid rural appraisal (RRA; citing Chambers, 1994), a household survey, and stakeholder workshops (Below et al., 2012). Farmer adaptation practices were scored for their feasibility and efficacy related to climate change and compared across the two regions (Below et al., 2012). Weights were derived in "an iterative stepwise approach using an established technique of a 5-point-Likert scale as proposed by Wyatt and Meyers (1987) as well as qualitative data collected during group discussions" (Below et al., 2012). The AAI analysis methods included qualitative content analysis, descriptive statistics, explanatory factor analysis, and a multiple linear regression model to yield determinants of adaptation based on 33 *adaptation practices* used by farmers (Below et al., 2012). An adaptation index sums frequencies of practices for the region and uses weighted adaptation practices for each farm that account for the farmers' opinions about the effectiveness of the practice and whether the practice is considered an effective way to improve resilience to climate change (Below et al., 2012).

Another assessment approach utilized in Columbia, was developed to compare agroecologically-oriented farms with conventional farms for their vulnerability to climate change--whereby the agroecological farms scored higher than conventional farms based on 14 farmer-identified indicators such as crop diversity, soil cover, water management, food production, and independence from external outputs (Altieri et al., 2015, citing research in Columbia by Henao

2013)). Using a scale of 1 to 5 displayed in radial diagrams to compare the vulnerability of farms in different communities, research confirmed that the capacity of farmers to respond to climate change was better for most of the six farmer-informed indicators on agroecological farms compared to conventional farms (Altieri et al., 2015, citing research in Columbia by Henao 2013)).

A final set of assessment tools we reviewed focused specifically on farm economic viability, including a wide array of benchmark, decision-support, and cost calculator tools and studies (Berry, 2009; Chase, 2012; Hendrickson, 2005; LeRoux, Schmit, Roth, & Streeter, 2009). Of particular interest for direct market urban farms, the Market Channel Assessment Tool (MCAT) helps farmers evaluate the effectiveness of their market outlets in terms of the labor, expense, and income associated with the activities required from harvest-to-sale in order to optimize decision-making (LeRoux et al., 2009). A final weighted ranking is calculated for each of a farm's marketing channels based on the factors above and incorporation of lifestyle and risk preferences.

In conclusion, the literature, tools, models, and assessment approaches reviewed for this research project illustrated many common or related indicators and themes of research. Many other tool developers also prioritized assessment methods that could be portable, time-efficient and adaptable. While strengths and weaknesses of each model were identified, like the other authors, we identified the need to develop a unique approach that would fit our particular situation and research questions. Thus, the tool we developed, the Farm Resilience Assessment Tool (FRAT), builds on, yet significantly modifies the indicator frameworks and methods featured in other models with an emphasis on operationalizing concepts of *resilience* [4] and principles of *agroecology* [5].

[4] *Resilience* in this project refers to the capacity of farms to grow food for local consumption over the long-term, whereby the farmer implements adaptive strategies to overcome challenges and complexity.
[5] *Agroecology* refers to the application of ecological principles to inform sustainable agricultural practices, and is integrated with the social context promoting transdisciplinary approaches to managing agroecosystems.

III. Understanding the County Context

To situate farms and food production in the context of Clark County, this section summarizes available secondary data suggesting that this county has (A) a significant and growing local agrifood sector that is (B) facing substantial challenges.

A) Clark County is Agriculturally Important (AI)

According to the U.S. Department of Agriculture (USDA) 2012 Census of Agriculture, the total market value of crops and livestock sold by Clark County farms was $50.9 million (3% less than 2007).[v] As an estimate of productivity for Clark County (and AI qualification), sales per acre of cropland was $650 (USDA, 2014). Clark County ranked highest in percent of area in farms among Western Washington counties,[vi] and had the highest number of farms direct-marketing, according to the 2007 Census of Agriculture (Ostrom, 2010). Between 2002 and 2012, the number of direct market farms in Clark County grew by 40% (Smee, 2015).

In addition to farm sales in the 2012 Census of Agriculture, 384 of the farms reported additional gross income from farm-related sources, totaling nearly $6 million—including $249,000 from agri-tourism and recreational services. Clark County farms' value in land and buildings is nearly $1 billion, with an average per farm of $490,000 (USDA, 2012). The market value of land and buildings can also be found for individual parcels in the Clark County assessor database.

Considering possible indicators of innovation and diversification, the 2012 Census of Agriculture reports Clark County as having 39 CSA farms, 141 farms producing value-added commodities, 43 farms with on-farm packing facilities, and 85 farms selling direct to retail outlets; 85% of the vegetables grown are "harvested for fresh market" (compared to being harvested for processing). Rotational grazing is practiced on 345 farms. There are 25 farms reporting that they use organic methods, generating a total $841,000 in sales, with 12 being Certified Organic (USDA, 2012). There was an 88% increase in the acres of vegetables reported between 2007 and 2012 (Smee, 2015). Production from the two industry classifications of "Vegetable & Melon" and "Fruit & Nut Trees" combined comes from 15% of all the farms in Clark County. As for farm operator diversity, 94% of principle operators are white male, and of the farms that only have one operator, 90% are run by women (USDA, 2012). Special programs and funding, targeting farmers who are young, new to farming, and/or belonging to "socially disadvantaged" groups, aim to address needs of the emerging agricultural sector. In Clark County, there is a network of Women in Agriculture.

B) Clark County's Agriculture Faces Significant Challenges

One of the most rapidly urbanizing counties in Washington (Born & Martin, 2011), Clark County is well-known for sprawling development (Williams-Derry, 2012). Clark County is purported to exhibit an agricultural sector in "transition" (Berk Consulting, 2012; Globalwise Inc, 2007). The boundaries between urban, suburban, and more rural areas are indistinct, as well. For instance, 34% of the land inside the Urban Growth Area (UGA) was still in forest and agriculture in 2005-2006 (Kline, Thiers, Ozawa, Yeakley, & Gordon, 2014: 61) as Clark County expanded its UGA boundaries into areas once dominated by rural, agricultural, and forest land-use designations. Reported for an analysis of urban growth area (UGA) expansion plans in 2007, 25% of the Clark County's commercial agricultural land was located within the UGA, and 15% of identified farms were mapped within the 2004 city limits (Globalwise Inc, 2007). Farmland is being converted to housing developments[vii] and roadways are encroaching on active farmland.[viii]

Between 2007 and 2012, the number of farms in Clark County fell by 8% comensurate with a 5% reduction in overall acres of land in farms, but the average size of farms grew by 5% to 39 acres. By total farmland area, the majority of the farms (86%) in Clark County are smaller than 50 acres in size, and they encompass approximately 37% of the total Land in Farm area (USDA, 2012). Of the total cropland harvested in Clark County in 2012, 25% was from the farms less than 50 acres in size. The dominance of small-acreage farms less than 50 acres is not a new nor recent phenomenon for Clark County agriculture, according to historical statistics (Globalwise Inc, 2007). However, planners and policy-makers in Clark County cite trends in Census of Agriculture data to justify land use decisions (Berk Consulting, 2015).

IV. Research Methods

This section outlines the research methods utilized to design and pilot test our new assessment tool, the Farm Resilience Assessment Tool (FRAT), beginning with the participatory aspects that informed the initial research questions and various stages of the project. This section then describes the considerations that informed the selection of an overall indicator framework based on four realms of inquiry and the data collection and scoring protocols that were followed for the selected indicators. Finally, outreach activities and plans are detailed.

A) Participatory Research and Assessment Tool Development

The research process for FRAT development and implementation involved ongoing *participatory* exchange from the project design through the implementation and analysis phases. The intent was to develop research questions pertinent to the context and important to the stakeholders. A core group of project stakeholder-advisors was established early on to include farmers and representatives from conservation, marketing, retail, real estate, non-profits, and Extension. Community partners were engaged to help with collecting baseline information about area farms, resulting in a master list from which the study farms were selected. Over the course of the grant, project summary updates were periodically shared with advisors to solicit their feedback. Most notably, the Food System Council informed the primary research question about what will be needed to enhance and sustain local food production agriculture in Clark County given the widespread and continued rapid rate of urbanization and land use conversion. Such ongoing engagement with stakeholder-advisors (farmers, agricultural professionals, market managers, and community organizations) for this research helped prioritize the indicators to include in the FRAT.

B) Pilot Tests

Informing the development of the FRAT tool and implementation process, trials of the interview and proposed field assessment procedures were conducted to refine the data collection methods and minimize the time required of the farmer participants. Preliminary results of our data analyses were shared with stakeholders to solicit feedback. In addition to practicing the semi-structured interview protocol with two advisors, we conducted on-farm trials at two urban agriculture sites to test methods for assessing soil management and biodiversity (beneficial insects and pest monitoring). We decided that such intensive field activities would be outside of the scope of our project due to their cost.

We also field-tested the Market Channel Assessment Tool (MCAT) protocol (LeRoux & Schmit, 2011) with one farm to inform the FRAT indicator selection and scoring in the market and economic realm. We wanted to see if elements of the MCAT approach could be adapted for FRAT pilot farms using multiple types of market channels. After a week of data collection, we processed the data using the MCAT spreadsheet (LeRoux & Schmit, 2011). We found that it was a challenge for the farm operators to track the multiple labor tasks associated with their different market outlets during the peak season. The results of the trial were shared with the farm operators, but there were gaps in the data, due to the demanding level of record-keeping. It appeared that the MCAT, with proper support, could be a viable decision support tool for such farms. However, the record-keeping and coaching required were beyond the scope of this project. Several concepts from this tool were incorporated into the FRAT indicators.

C) Identifying Direct Market Farms to Pilot the FRAT

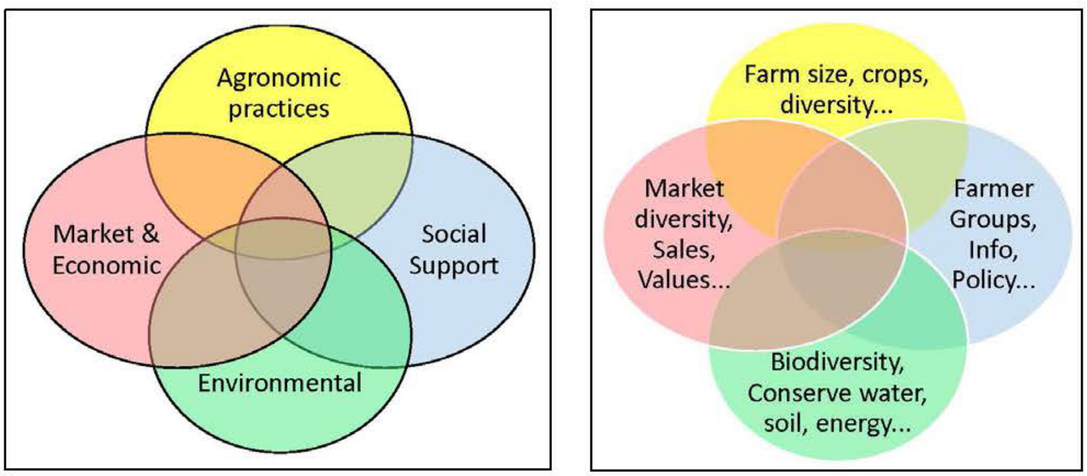
Baseline data on food farming in Clark County was compiled from multiple sources including agency farm lists, web-searches, and online County parcel information. Contextual farm data was also collected through participant observation and networking at farmer-focused and food system events (farm tours, farmers markets, community meetings, and conferences). A farm list with parcel information was compiled from the sources above and from lists maintained by WSU Extension, Clark Conservation District, and the Clark County Food Bank. In 2015, we counted seven consistent farmers markets and more than 20 active CSA farms. More than 40 roadside farm stands were mapped in 2008 for the food system assessment (Gilroy, 2008).

The master farm list includes 100 farms that are using one or more direct-to-consumer market channels. Based on identified farm characteristics, the final sample of 23 farms was selected from the list to pilot the FRAT. They all raise vegetables and/or fruits and use direct market channels as part or all of their farm operations. They were purposefully selected to vary on many other attributes such as management practices, market outlets, size, land tenure arrangements, operator age, and length of time in farming.

D) Framing the Farm Resilience Assessment Tool (FRAT)

We developed a conceptual framework that delineates four main realms of resilience: (1) Agronomic Practices, (2) Market and Economic Factors, (3) Environmental Dimensions, and (4) Social Support. These four realms provide overarching categories for developing a set of indicators, collecting data, analyzing results, reporting, and evaluation. Three primary aspects of resilience were considered in constructing this assessment framework: (1) Buffer capacity (understanding and optimizing natural cycles, diversity and flexibility, and stewardship); (2) Self-reliance and ability to self-organize (decreased reliance on external inputs, and global markets); and (3) Capacity for learning and adaptability (learning, and feedback mechanisms) (Milestad & Darnhofer, 2003). Key adaptive strategies and practices hypothesized to be important to the agronomic, economic, environmental, and social resilience of a farm were specified and associated with likely farm system attributes and challenges. Indicators were then developed to measure these different aspects of resilience as informed most significantly by the following: International organic certification standards set out by the International Federation of Organic Agriculture Movements (IFOAM) (*see* Milestad & Darnhofer 2003)); the "public goods" assessment tool indicators developed by Gerrard et al. (2012) in the UK; and the related behavior-based resilience indicators for agroecological systems proposed by Cabell and Oelosfse (2012). Based on these constructs, 29 indicators were developed to correspond with the four-realm framework depicted in Figure 1, below. Interview questions and scoring criteria were designed to collect and tabulate data for each of the 29 indicators for each farm.

Figure 1: Conceptual Framework for FRAT Indicator Realms (Left) and Examples (right)



E) Data Collection & Compilation

On-farm assessments consisted of semi-structured interviews with farmers and site observations. The farmer interview questions and site assessments were designed to gather data to characterize farm and farmer attributes, probe farmer perspectives in-depth, and address each of the indicators within the conceptual framework. Select data were then entered into spreadsheets for indicator scoring and analysis. Farms were scored for 29 indicators, each associated with one of the four realms. Initial, unweighted outputs for each individual indicator are listed in the Results of the FRAT Preliminary Analysis section below, with additional information contained in the Appendix.

F) General Considerations of Scoring and FRAT Outputs

The approach for the FRAT uses predetermined criteria to score each of the farms on 29 different indicators based on the data collected during the interviews, farm parcel information, and site observations. Scores are based on a 5-point scale, with one for the lowest score and 5 for the highest. The criteria used to develop the scoring categories for each indicator are summarized in the Appendix. Scoring offers an approach to categorizing a variety of data types so it can be systematically analyzed across different types of indicators and across different types of farms. A scoring system provides a broad framework that can also serve to inform more in-depth qualitative data analysis, a strategy elaborated in Abeyasekera (2005). "Most scales in social sciences are *category scales*" (Bernard, 2012: 307). Complex data are coded and structured in a systematic way so as to transform information into forms that can be analyzed for meanings and patterns particular to the research questions posed (Abeyasekera, 2005).

The 29 indicators comprising the FRAT can be viewed as an index or a "complex scale" comprised of multiple indicators (Bernard, 2012: 287). Using Bernard's (2012) definitions, in their simplest form the FRAT scores by indicator can be seen as a "composite measure" with equal weights given to each item for a "cumulative index." The four framework realms above were investigated in a way that will allow the calculation of sub-scores and an overall compiled score (Bernard, 2012: 294). A common example of an aggregate index is used in the international policy arena in the form of the Human Development Index (HDI) of the United Nations Development Program (UNDP); HDI uses equal weights applied to the main dimensions, each of which is calculated from sub-indices (Chowdhury & Squire, 2006). Once initial analyses and evaluations of the FRAT have been completed, it may make sense for indicators to be weighted differently in forming sub-scores and a composite score. While an aggregate score can be calculated for each farm based on the scores for individual indicators and reported to individual farmers, to ensure confidentiality this report only presents aggregated farm results.

Scores for each indicator can be summarized using a simple statistical average (Abeyasekera, 2005; Norman, 2010), as was done for some of the assessment tools reviewed for this project (Cândido et al., 2015; Gerrard et al., 2012). To consider whether the average actually reflects the central tendency of the range of scores received by the different farms as a group for each individual indicator, we also calculated the median and the mode for each item. Finally, to assist with understanding the extent to which the study farms as a group scored positively on different indicators of resilience we looked at the frequencies for which scores of 4 or 5 were received for each item.

Our initial data are presented in simple bar graphs and tables by indicator and by indicator realm to help stakeholders view both the different components and the integrated system being analyzed. The different measures provided help to give a sense of the group norms and the relative strengths and weaknesses of the farms in aggregate. We may develop more graphical representations to integrate our data once we evaluate the efficacy of the different indicators we tested and consider a possible weighting system. For example, radar diagrams are commonly used for such multi-criteria analyses, including the integration of different farming system indicator realms because such visual representations can be readily understood by stakeholders (Gomiero, Giampietro, & Mayumi, 2006).

G) Data Analysis: FRAT Scoring Criteria Development

Based on the resilience framework developed, scoring criteria were applied to key indicators in the agronomic, social, environmental, and economic realms—resulting in the Farm Resilience Assessment Tool (FRAT) outputs. The FRAT adapts and utilizes standards from the key models and tools we reviewed as described previously. For example, several of the "public goods" tool scoring protocols, found in the Gerrard et al. (2012) spreadsheet, were adapted into the FRAT, such as crop and varietal diversity, soil testing, biological controls, water system adequacy, and farmer experience (FRAT indicators A-4, A-5, A-7, A-10, E-5, and S-2, respectively).

The scoring criteria of the SHARP tool also informed the refinement of the final FRAT scoring and analysis. For example, the SHARP tool provides pick-lists of production practices, participation in groups, and other indicators, and then tallies the number of practices utilized. To obtain indicator scores, these attributes were coded and sorted into a range of pre-set categories corresponding to each indicator and documented in the FRAT spreadsheets. The protocols and criteria for scoring are summarized in the Appendix. For attributes scored for resilience according to a range of values, the use of *less than* or *greater than* for the lower and higher score categories, respectively, follows on other assessment and reporting models (such as for 35 of the 59 questions in the SHARP tool: Choptiany et al., 2014). For example, in keeping with the regional context, a score was assigned from one to five based on the acreage of the farm, with one being the smallest farm category (under 10 acres) and five being the largest farm category (greater than 50 acres). For context, farm size is reported by acreage category and range of gross sales in the Census of Agriculture (USDA, every five years).

FRAT agroecological scoring criteria were also informed by several other models. We adapted ecological diversity indicators from Gliessman's agroecology textbook (Gliessman, 2014) and Guthman's research on organic farming practices (see the Appendix of Guthman, 2014). Additionally, Nicholls et al (2004) score *vegetative diversity* for areas surrounding farms and in crop areas as informs Environmental indicators E-1 and E-2 in the FRAT. These same indicators are evaluated in the MESMIS model (Speelman & Garcia-Barrios, 2010), and are similar to two SHARP tool indicators for environment and production systems (Choptiany et al., 2014).

Similar to the SHARP tool (Choptiany et al., 2014), the FRAT is not meant to be an absolute resilience measurement tool, even though scores are assigned to the indicators. The outputs are a set of comparatively scored indicators to inform an *assessment* of resilience with consideration of the context. The primary goal of implementing an assessment tool is to generate informed discussion around prioritizing solutions and interventions where they are most needed.

H) Outreach

After the process of collecting on-farm assessment data, initial summary findings were shared with research participants and project advisors in order to solicit their feedback. An important research instrument of this project was the farmer-only roundtable convened in early November, 2015. Farmers who participated in the meeting provided additional information and contributed their evaluations of the tool. The roundtable was multi-functional in that more information was gathered, some results were confirmed or expanded upon, and it led to some FRAT scoring criteria modifications. As FRAT research confirmed the need for more farmer networking opportunities, the roundtable offered one such venue.

Farmers learned about other farmers' approaches to some common problems, and identified ways farmers could work together to overcome hurdles. They made future plans to learn more from one another. Examples include participating in soil management classes offered by a soil scientist farmer, and sharing Organic orchard management strategies. Farmers appreciated that researchers are interested in helping to identify (and pursue) solutions. Preliminary results were also shared at the monthly meeting of the multi-stakeholder Food System Council (including farmers), in late November, 2015. Based on a need identified by several farmers, one Council member volunteered to research farm internship models that might be applicable to Clark County.

V. Results of Preliminary FRAT Analysis

This section first summarizes the characteristics of the participating farms. Next we summarize FRAT data and output results with details presented in bar charts and tables, organized by agronomic, market/economic, environmental, and social indicator categories. Qualitative data are used to help elaborate the scoring results.

A) Participating Farm Characteristics

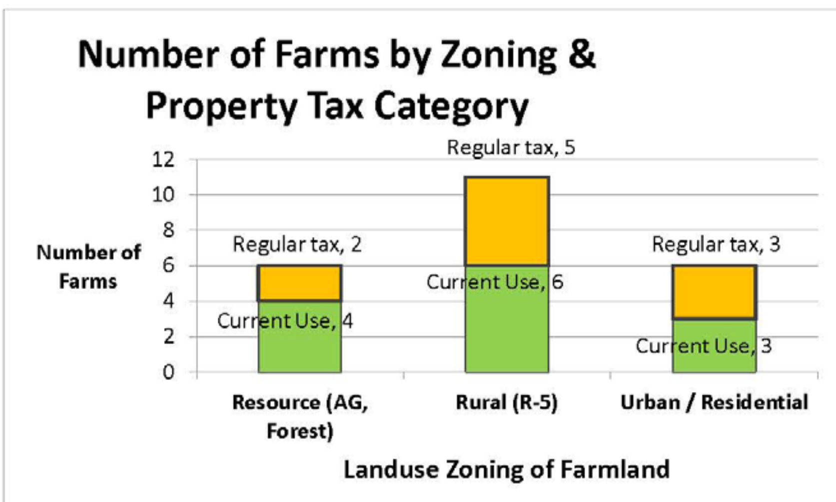
1. Farm Location

a. Urban Area Zoning and Land Use Property Taxation

This diverse sample of direct market farms are variously located in rural areas, among mixed residential suburbs, and within densifying City neighborhoods. Several farms are adjacent to the Urban Growth Area (UGA) boundary. The bar chart below shows the zoning and tax status of the 23 farms selected for the FRAT pilot. The farmland falls into three categories of land use zoning, according to Clark County Assessor's data on the parcels themselves: Resource (agriculture or forestry), Rural, and Urban/Residential).

The County website parcel information also specifies whether the property tax assessment is based on market value (regular) or is reduced because of the land use designations under "Current Use" taxation. Property tax is reduced for 13 of the farms based on "Current Use" for agriculture, forestry, or open space, as shown in the bar chart below.

Figure 2: Number of Farms by Zoning & Property Tax Category

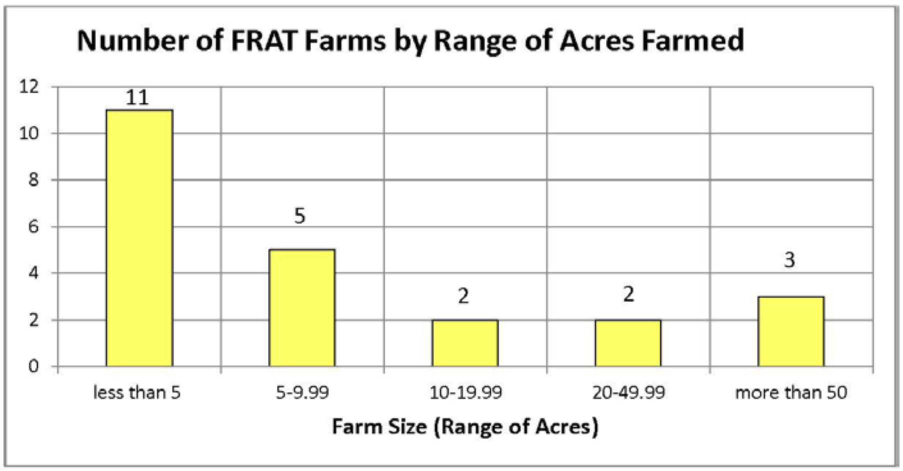


Current Use is the only farmland protection measure in Clark County, besides the "Right to Farm" ordinance. A recent survey of direct market farms in Clark County indicates an increase in participation by landowners in the Current Use tax-reduction program over the last decade, and an overall satisfaction with the program (Smee, 2015). However, landowners expressed the need for more support for farms to address a host of issues such as "zoning, development pressure, neighbor disputes, labor, and consumer outreach" and expressed that "insecurity or volatility of farming" is a bigger concern for them than Current Use program reform (Smee, 2015).

2. Farm Scale Indicators

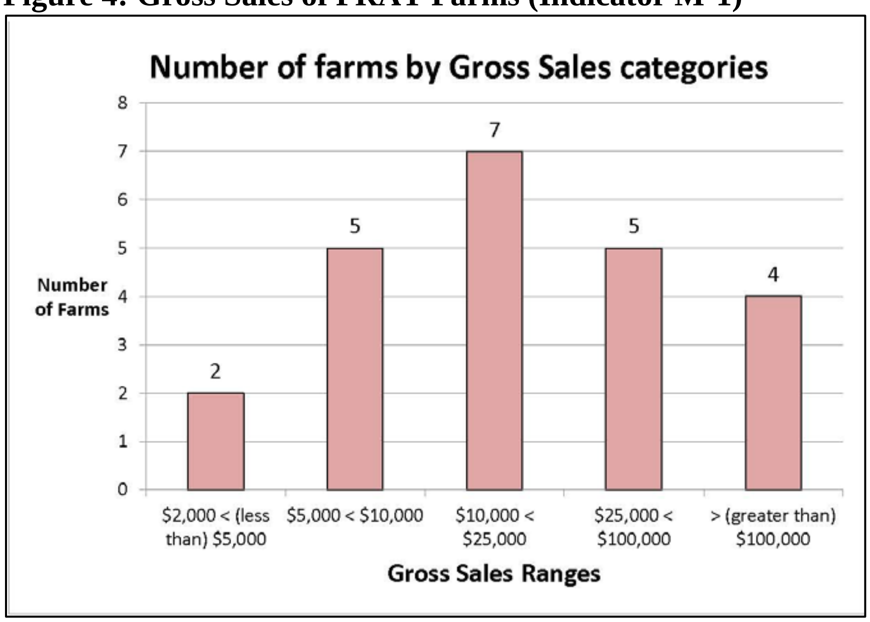
The total land base represented by the 23 farms is approximately 616 acres. About 66% of the land is estimated to be the acres of farmed land (in active crop production or forage). FRAT farm size ranges from less than five to over 100 acres, representing a diverse range of operational scales. The number of farms by range of acres farmed is shown in Figure 3 below.

Figure 3: Indicator A-1: Farms Scale in Acres Farmed



The FRAT farms range from less than $5,000 in annual gross sales to over $350,000.[ix] Figure 4 below shows number of farms by range category.

Figure 4: Gross Sales of FRAT Farms (Indicator M-1)



The 2012 Census of Agriculture reported the Value of Crops per Cropland harvested as an average of $782/acre for Clark County. The apparent range of sales-per-acre farmed varies widely for FRAT farms, estimated from the gross sales and acres farmed reported in our study. The approximate sales-per-acre farmed averaged for all FRAT farms is over $6,000 per acre, but ranges from less than $500 to more than $10,000. The wide range in sales per acre is likely affected by the type of crop, the intensity of operation, the level of inputs, and whether livestock acres are included. For another point of reference, members of the Clark County Agricultural Preservation Committee "suggested that well-managed high value agricultural producers are capable of grossing $8,000 to $12,000 per acre in Clark County" (Globalwise Inc, 2007), which some FRAT farms appear to be attaining.

B) Summary of the FRAT Results by Indicator Realm

In this document, FRAT results are primarily discussed for the farms as a group to protect the confidentiality of individual farms. Overall, as an aggregate group, the farms tend to fall in the middle on the scales of 1 (lowest) to 5 (highest) for each of the FRAT realms discussed in detail below. See also the summary tables with further details on the scoring criteria for all 29 indicators in the Appendix. This section features the four separate tables of FRAT indicators, one table for each realm, and a brief discussion of preliminary results. For each of the 29 indicators, the average, median, and modal score for all the farms is reported, as well as the frequencies with which farms scored a 4 or a 5. The scoring scale is always from 1 (low) to 5 (high).

1. Agronomic Indicator Results

The table below shows the average, median, and mode for the FRAT scores for all of the 11 Agronomic indicators. We also calculated the percentage of study farms who received a score of either 4 or 5 (the column labeled % ≥ 4 in the table).

Table 1: Agronomic Indicators, Descriptive Statistics, General Criteria

A = Agronomic						
#	**Indicator**	Mean	Mode	Median	**% ≥4**	**General Scoring Criteria (Score of 1 low; 5 is highest)**
A-1	Acres farmed	2.2	1	2	26	Scores based range of acres.
A-2	Access to land	3.7	5	5	52	Adequacy of current land base
A-3	Product Integration	2.3	2	2	13	Number of product types
A-4	Crop diversity	4.6	5	5	87	Number of crop types
A-5	Varietal diversity	2.2	2	2	9	Number of varieties produced
A-6	Weed management practices	2.9	3	3	22	Number of strategies used
A-7	Biological control (BC) methods	1.8	1	2	9	Number of methods used
A-8	Practices that increase biodiversity	3.0	3	3	30	Total number of practices used
A-9	Input guidance	3.3	4	4	57	Number of practices
A-10	Soil testing	1.6	1	1	9	Frequency of soil testing
A-11	Innovative Strategies	3.9	5	5	61	Number of strategies

The majority of farms are smaller than ten acres in size (A-1). Overall, the farms appear to have a relatively adequate land base to meet their current goals (A-2 average score is 3.7, with a median score of 5). However, 8 farmers said they would like to expand their acreage, and 12 farmers said they could increase production on their current acreage if market conditions and/or access to labor improved.

Diversity is considered in several different indicators. Growing a diversity of products, crops, and varieties can *buffer* the farm from losses or failures due to disease or weather conditions. Using a variety of strategies for weed or pest management, each adapted to the particular situation, and minimizing external inputs, could indicate improved resilience as well. On the other hand, focusing on fewer more effective strategies could improve farm systems.

The lower scores for A-3 reflects a low number of farms with multiple types of product, as the majority of farms are focused on vegetables without animals or significant orchards. The farms score high for crop diversity (A-4), reflecting that most farms grow more than 15 types of vegetables. The CSA and market garden farms grow a wide array of types of vegetables.

Several farms grow more than one variety of several of their important crops (A-5), such as tomatoes. However, overall the varietal diversity score is low (A-5), with a wide range for individual farms. FRAT farms use a diverse array of weed management strategies (A-6). For biologically-driven pest management (A-7) tactics, all the farms have some type of planting strategy for attracting beneficial insects.

As diverse as the 23 farms are, most pursue sustainability using practices that enrich their soil and contribute to ecological diversity. Farmers use numerous management practices that improve ecological diversity, with medium scores on indicator A-8 (A-8 uses the list from Figure 17-2 in: Gliessman, 2014). Common practices among FRAT farms include strip-cropping, cover-cropping, crop rotations, high inputs of organic matter, and reduction of chemical use. Less commonly used practices on the list are minimum tillage, hedgerows, fallows, and integration of livestock. In addition, all farms practice some type of internal cycling of "waste" materials. Few farms have major investments in hedgerows. Some farms are naturally diverse (see also E-1 and E-2).

While some farms report being "beyond organic," many use some commercial Organic inputs for pests, weeds, and/or fertilization (the A-9 average score is 3.3). The majority of farms use inputs approved for use on Certified Organic farms, and some use conventional type chemicals. Only 57% received a score of 4 or higher on this indicator.

We found that soil testing is not a common or regular practice on most of the FRAT farms with "1" being the mean and median score on A-10. However, farmers do monitor crop health, yields (in general, or by sales more often than by weight), and other factors. They often record their observations or practices (such as inputs and timing) in notebooks. Farmers conduct trials of different species, inputs, rotations, and other practices. Some comment that they learn from mistakes as well as successes. Most farmers expressed interest in collaborative on-farm research, and at least three have been engaged in research.

FRAT farms have used many different innovative, problem-solving strategies indicating adaptations to improve farm resilience (average score for A-11 is 3.9 with a median of 5). The most common strategies used by the farms include changing the market outlet mix, expanding market development, and investing in farm infrastructure such as irrigation improvements and/or farm store expansion. Certification is the least common innovation, even though most farms claim using organic practices. Several farms increased agritourism or collaboration. Although minor crop mix changes are common, major changes are less common. Some farmers got involved in organizations to try to affect changes. High levels of innovation (in multiple realms), and flexibility, could indicate adaptability.

2. Market and Economic Resilience Indicator Results

The table below shows the score and scoring criteria for each indicator in the market and economic realm. Additional information is provided for three of the indicators—a gross sales bar chart (Gross Sales of FRAT Farms (Indicator M-1) graph, Figure 4, page 20), a market channel bar chart (Figure 5), and a bar chart showing the number of farms identifying with each risk category (Figure 6, page 26).

The results confirmed that farmers pursue a diverse range of economic strategies. However, more than half the farms have been in business less than 10 years (M-2), and three will not be in business in 2016. The farms have considerable value in their land and buildings (M-3).

On average for all the pilot farms, land tenure scoring (M-4 median score of 5) reflects a good level of "control" over land, even though half of the farms lease some or all of the land they farm. Most of the farms (83%) score 4 or 5, including family land leased to the farm business relatives; 2 farms have short term leases with non-related, non-farming landowners (score=1). About 37% of the total farmed acres of FRAT farms are leased by 12 of the farms.

Table 2: Market/Economic Indicators, Descriptive Scores, and Criteria

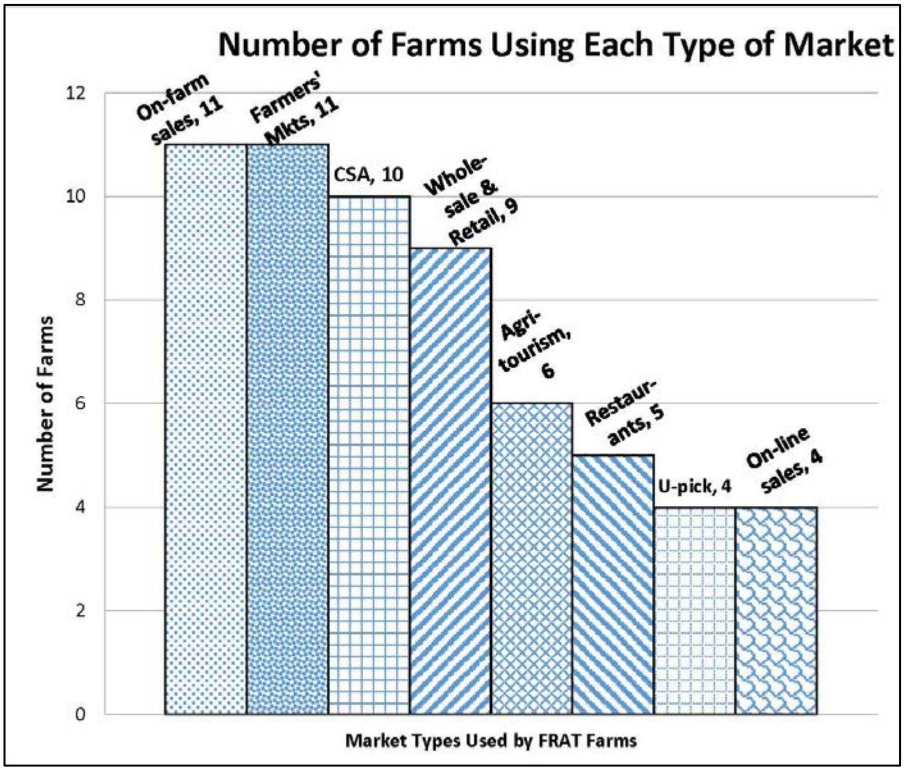
M = Market/ Economics						
#	**Indicator**	Mean	Mode	Median	% ≥4	**General Scoring Criteria**
M-1	Gross Sales	3.1	3	3	26	See categories in Figure 4
M-2	Years in business	2.3	1	2	17	Number of years, by category
M-3	Value in Land & Buildings	3.4	4	4	52	Market value, by category
M-4	Land tenure (own, lease)	4.3	5	5	83	Level of ownership and/or lease
M-5	Post-harvest Capacity	2.6	2	2	17	Capacity for washing, packing, storage, etc.
M-6	Diversity of products	2.2	2	2	13	Number of other products
M-7	Diversity of markets	3.3	2	3	48	Number of market channels
M-8	Risks to commercial viability	2.7	3	3	13	Scored by number of risks

Market Channels of FRAT Farms

The 23 farms market directly to consumers using one or more of ten different market channels is shown in Figure 5, not counting self-provisioning and charitable donations. Based on the number of channels used, the average score for market diversity (M-7) is 3.3. Just under half of the farms received a score of 4 or 5. The mix of Farmers Markets utilized evolves over time for many farms: 11 farmers reported having stopped using one or more Farmers Markets over their history, and one farm will stop going to a Market in 2016.

The farms have core loyal and ongoing repeat customers, and most farms sell out of product (and/or distribute to the Food Bank, family, animals, or a compost pile). However, many state that more customers and better markets or outlets would improve their economic viability. Over half the farms are seeking more markets and/or better performance, such as more reliable, consistent CSA clientele. Many farmers in the study expressed interest in more opportunities to aggregate their products with other farmers to serve larger or more distant markets such as restaurants or institutions.

Figure 5: Market Outlets for the FRAT Farms (Indicator M-7)



Additional market diversity is not shown in Figure 5, nor measured in the scoring. For examples, some farms participate in more than one Farmers Market, and some retail outlets have more than one location. In addition to the market channels, for 16 of the farms, families consume a significant proportion of farm output. Several farms progressed from intensive self-provisioning in large gardens to commercial market gardens and ongoing farm businesses. Several farms reported donating produce to the Clark County Food Bank, a food pantry, or a shelter. Other informal product marketing cooperation takes place among farmers, friends, and associates. Product aggregation is already part of farm store operations, but products sold in farm stores are not all sourced from within Clark County. Farmers discussed having a wide range of products as being good for meeting customer desires.

Risks to Commercial Viability (M-8)

Farmers discussed the issues they considered to be risks to their farm's commercial viability during the interviews. The bar chart below shows the number of farms identifying with each risk category. As for strategies to overcome risks, FRAT farms have a diversity of financial and labor support systems. For 10 farms, at least one household member of has an off-farm career job. Within 11 farm households, one or more people are retired, so they contribute financial support for the farmer(s), and/or farm operation labor.

Marketing risks were commonly identified, along with production risks. Although market diversity can buffer market risks and help ensure produce is sold, having numerous channels may not necessarily be the most sustainable strategy if labor or other resources are spread too thin. For example, one very diversified farm with integrated livestock and multiple market channels recently stopped commercial farming altogether, after first dropping some of the unprofitable products (turkeys, for one). This (former) farm is one of 8 farms originally targeted for participation in this research that ceased or greatly diminished operations in the last few years.

Several new farm operations have started during the course of this study. Market outlets have changed as well, decreasing opportunities for some farms. In the same period, five retail-to-consumer marketing outlets that sold local produce are no longer operating, including the Uptown Urban Farmers' Market and Vancouver Food Cooperative. Some farmers have demonstrated adaptability by making business model modifications in response to changes in market availability and/or consumer feedback

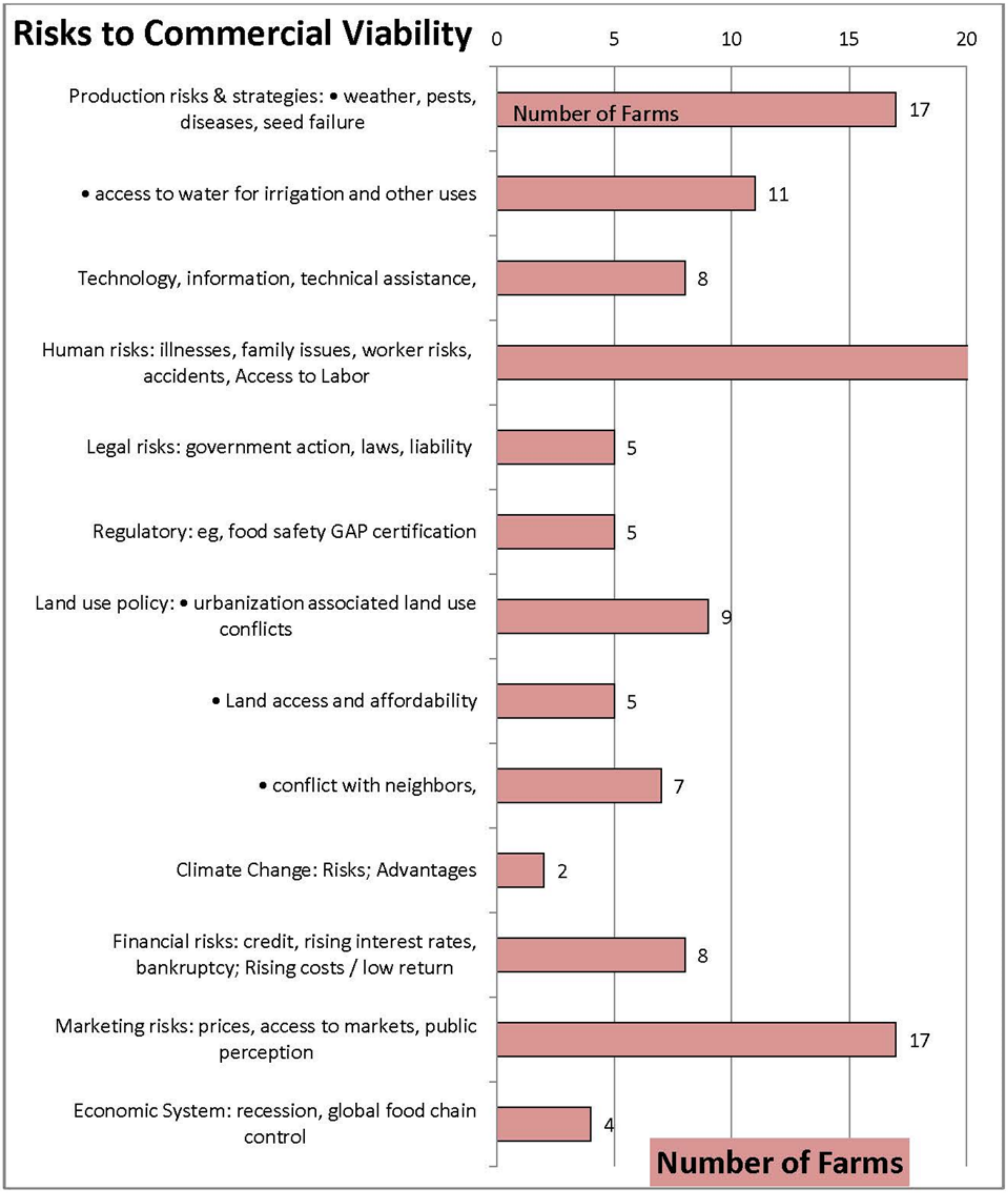
Human Risks: Family and Labor

As shown in Figure 6, human risks were evident for most of the FRAT farms. In particular, family, health, and/or labor issues are notable for farms. Human (family and labor) issues are also evident in the number of FRAT farms (3) who will not be in commercial farming for 2016. Of the FRAT farmers, 14 are over the age of 55 years, which is close to the 58-year average age of farm operators in Clark County (USDA, 2012).

Labor is reportedly a limitation for small family farms that cannot afford to pay outside help. The possibility of having interns, often a common strategy for the small farm sector, is considered by many study participants to be too burdensome at this time due to regulatory and logistical barriers. Several young farmers interned on other farms before starting their own, so they know the mutual values of such experiences.

Labor is a limitation for farms who do (or would) hire non-family members, due to a reported lack of availability of experienced and reliable workers. Several fruit growers (including a few not in the FRAT sample) reported that they offer u-pick opportunities in part because the fruit otherwise might not get picked when it is ready. Impressively, the 23 operations employ the approximated full-time equivalent of 32 family member farmers. Seven farms employ additional non-family members.

Figure 6: Risks to Commercial Viability (M-8) for FRAT Farms



3. Environmental/Conservation Indicator Results

Naturally occurring vegetative diversity is more prevalent for the rural farm parcels adjacent to streams or forested parcels. Farms in more urban settings, surrounded by developed land, score low (E-1). Most FRAT farms cultivate some level of vegetative diversity in their fields (E-2). Scoring was based on estimations from parcel vicinity map imagery and field observation of the land surrounding the farmed area (criteria after: Nicholls et al., 2004). Farms in more urban settings, surrounded by developed land, score low on E-1. Most FRAT farms cultivate some level of vegetative diversity in their fields (E-2), estimated from parcel map imagery and field observation of the crop fields. Few FRAT farms have “mono-crop” areas other than some orchard areas, and some orchards incorporate vegetative diversity.

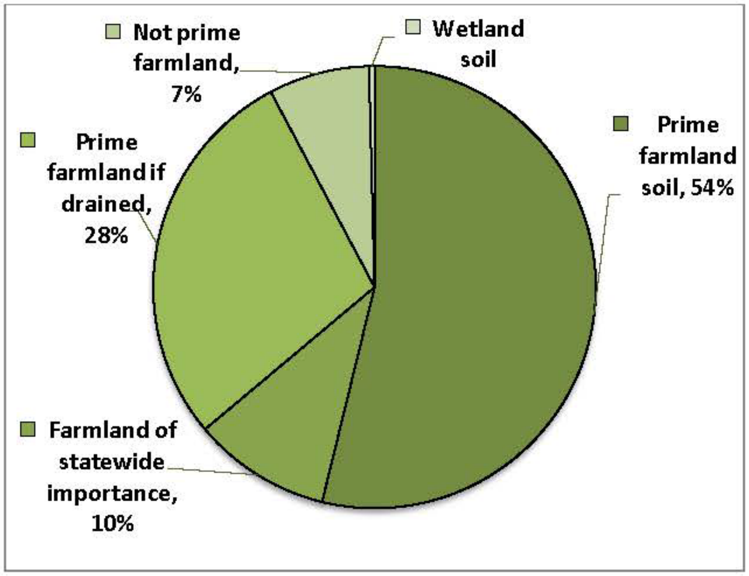
Table 3: Environmental Indicator Descriptive Score Results and Criteria

E = Environment / Conservation						
#	**Indicator**	**Mean**	**Mode**	**Median**	**%≥4**	**Criteria**
E-1	Outside crop area veg. diversity	3.7	5	4	61%	Level of natural vegetation in surrounding area
E-2	In crop field area veg. diversity	3.0	2	3	39%	Level of vegetative diversity in/near crop area
E-3	Farmland soil class	2.9	3	3	30%	USDA Soil Survey farmland capability
E-4	Conservation by Irrigation methods	4.0	5	4	65%	Irrigation practices
E-5	Water source availability and adequacy	3.7	5	4	52%	Adequacy of water supply

Water-conserving measures are common features of FRAT farms (E-4), and most farms have a relatively adequate supply of quality water. Indications of diminished supplies are considered by some farmers to be related to neighboring residential well development. One farm never got a response from the Department of Ecology (DOE) about their water right application submitted 16 years ago, so they operated very conservatively on their domestic well, and assumed their use was “illegal.” Recently, based on our request for clarification through this project’s collaborative network, DOE indicated that use of domestic wells for farming is legal. Staying below the “5,000 gallons per day limit” is indeed an “Exempt” use of well water for agriculture (industrial use)—Exempt from Water Right Certification. Access to water can be a significant barrier for the agricultural sector, as rights have been lost in property transfers, parcelization, and development.

FRAT farms have relatively good inherent soil properties (E-3), with approximately 90% of the soils considered very good for crop farming in the soil survey (USDA, 1961—which is still referenced in the context of agricultural zoning designations in Clark County). The proportion of farmland in the various soil types and classification was estimated from Soil Survey maps showing the farmland. Only 2 farms scored low on E-3 (see Figure 7 below).

Figure 7: Soil Survey Farmland Suitability, All Farms (E-3)



4. Social Infrastructure Resilience Indicator Results

Reflecting their commitment to farming (S-1) across a wide range of experience (S-2), most of the farmers consider farming to be their primary occupation, although it is a second career for one or more of the operators on 11 of the farms. Fifteen of the farmers have been farming less than 10 years; some grew up on the farm.

Table 4: Social Indicators, Descriptive Scores, and Criteria

S = Social Infrastructure						
#	Indicator	Mean	Mode	Median	%≥4	General Scoring Criteria
S-1	Purpose and goals	3.3	4	3	43	Commitment to farm business
S-2	Experience in farming	2.6	2	2	22	Number of years farming
S-3	Participation in groups	2.0	1	2	4	Number of groups, associations, or networks
S-4	Information sources accessed	2.6	1	3	22	Number of sources used for learning, support, sharing
S-5	Urban neighbor problems	3.7	5	4	61	Number of problems identified

While all farmers have participated in some type of farmer group at some time to share or access information (S-3), informal networking is a more common way to obtain information and build cooperation than membership in formal farmer organizations. Formal groups include the Farm Bureau, Portland Area CSA Coalition, Food System Council, NW Direct Market Farmers, and product-specific associations. Some collaboration is informal and could be ongoing or intermittent, such as at marketing venues or special events similar to farmers' markets. Several farmers expressed a need for greater farmer-to-farmer networking. At the post-interview roundtable meeting, farmers identified additional opportunities to cooperate and exchange information.

For technical assistance (S-4), numerous FRAT farmers have participated in Extension programs such as business planning, rural land management, master gardening, value-added grant workshops, and farmer-to-farmer gatherings. They also noted that conferences often offer more in depth information, such as technical presentations at annual meetings of the North Willamette Horticultural Society or Tilth Producers of Washington. Farming technical assistance provided by WSU Extension, Clark Conservation District, and the local USDA offices of Rural Development and the Natural Resource Conservation Service (NRCS) was appreciated. However, many farmers expressed a need for more advanced training and more individualized assistance that is directly relevant for their farm, including on-farm consultations.

The more urban the farm's neighborhood, the more likely the farm is to have conflicts or problems (S-5). Some farmers reported no problems and several said they benefit from neighborly relations. See also the types of locations (urban, rural) for the farms in the bar chart above, Figure 2, page 19.

VI. Evaluation of the FRAT

The overall FRAT score for a farm, or for the participant farms as a group, is not meant to be judged as an absolute value for the *complex variables* comprising our index. The criteria used, the categories of indicators, and the combinations used to generate FRAT results are based on assumptions derived from the literature, as informed by other models reviewed. This report summarizes our preliminary analysis of the empirical data including farmer-reported information and secondary sources. Further in-depth analysis of interview and on-farm assessment data will undoubtedly reveal more nuance and particularities to the farming systems investigated. Armed with the more extensive preliminary findings, such as in this report, we will make decisions as to which indicators and scoring criteria appear to be most reliable. Additional farmer-feedback and further analysis of our qualitative data will provide valuable input on these determinations.

The best way to interpret the resilience remains open to interpretation. Whether analyzed as an aggregate summative score, as average scores, as median scores, or as simple frequencies, farms have moderate qualities of resilience, and clearly improvements are needed in some areas. Surprising strengths such as the security of land tenure were uncovered as well. In the future, upon further analysis additional indicators could be added, revised or subtracted based on their explanatory value. Weighting criteria for importance could be applied to indicators to provide further distinctions among variables and scores, as well. In the meantime, version one FRAT results are presented in this report. For the further analysis of outputs from the FRAT, scores and criteria can be cross-referenced to other studies, theoretical bases for resilience and agroecology, and our empirical data.

E) Recommendations for a FRAT Version-2 Process

FRAT version 2 should incorporate more opportunities for the farmers to score themselves. In Clark County, the farmers seemed to appreciate the attention of researchers who consider their perspectives important. In SHARP applications, the farmers are in Farmer Field Schools, so already participating in group and guided learning activities in their region along with technical assistance providers.

Farmers appreciated being invited to participate in farm resilience research, but their time is extremely limited. Interviews and on-farm assessments had to be kept short. This project was a pilot development phase, so the “tool” can hopefully be made more efficient from data collection to analysis in the future.

As for a portable tool, with significant modifications, the concurrently developed SHARP tool looks the most promising. We could adapt the SHARP tool to this farming system, since there is considerable overlap with the FRAT. SHARP features an application for an android tablet, which is user-friendly and obviously portable. Data collected in the field (by the farmer or researcher interviewing the farmer) can be uploaded into an Excel spreadsheet for the researcher to analyze further. Some results are almost immediate, on the tablet, so the feedback time from data to a preliminary summary is short. The extensive technical investments in the SHARP tool have already been made by the FAO, and SHARP has been modified with a modest budget for particular community applications so it may well prove useful to adapt.

One of the interesting aspects of SHARP implementation is that the farmers are already participating in a field school with other farmers and technical experts. Such a culture of research could be cultivated here. Participating farmers’ expressed a desire for more networking, farm tours, and shared learning opportunities. Whether for individual farmers or small groups of farmers, the SHARP tool also facilitates feedback on the scoring and prioritization of indicators, which would be a crucial process to engage before launching a FRAT version 2.

VII. Summary

This document reports on the results of a BIOAg grant research project, providing background on the project, the research process, the preliminary FRAT outcomes, and the initial results. In-depth data analysis will continue over the next year as part of graduate student Judith Wait’s dissertation, allowing further review and dissemination of these research findings.

The *Agroecological Assessment of Farming in the Rural-Urban Interface* project involved the development and implementation of a Farm Resilience Assessment Tool (FRAT) using indicators of agronomic, social, economic, and environmental resilience. Data gathered from 23 direct market farms producing vegetables and/or fruit in Clark County was compiled and analyzed to produce the FRAT scoring for the 29 indicators presented in this report. Data from the 23 on-farm assessments (semi-structured interviews and site observations) was augmented by County Assessor parcel information and farm websites, as well as participant observation during Farmers Markets, farm tours, and other events. Initial FRAT results were shared with farmers, advisors, and other stakeholders to solicit feedback and gather additional information.

As *Building Resilient Regional Food Systems* in the project title infers, one goal of conducting the *Assessment* with a diversity of farms is to illuminate ways in which current farming operations contribute to a resilient food system. All the farms included in the FRAT analysis grow vegetables and/or fruit for local consumers. They demonstrate their commitment to the pursuit of sustainability through their practices, such as water conservation (E-4), soil enhancement (A-8), and using biologically-based pest controls (A-7). They all use practices that contribute to ecological diversity (A-8).

By the criteria used for the FRAT, the farms (in aggregate) score in the middle of the scale, or "moderate." Overall, these farms have moderately adequate access to land, water, and productive soil for current operations (indicators A-2, M-4, E-5, E-3). Not surprising, the farms within more urbanized neighborhoods experience more problems, but for the group in aggregate, the FRAT score is 3.7 for indicator S-5 (relationships with neighbors).

In addition to pursuing innovative strategies to improve farm viability (A-11), the results also confirmed that farmers pursue a diverse range of strategies to reduce risks in multiple realms. In terms of FRAT scoring, the farms (in aggregate) score highest (above 3 on a scale of 1 to 5) for the following indicators: crop diversity (A-4), organic inputs (A-9), market diversity (M-7), using water-conserving irrigation methods (E-4), and commitment to farming (S-1).

Diversity, both on farms and across farms, is considered a key component of farm resilience (Milestad & Darnhofer, 2003). Diverse cropping systems using biologically-driven practices were fairly common. FRAT farms use a wide array of agroecological practices, and individually (on average), score in the middle of the scale. FRAT farms are a diverse group of farms, in terms of their scale of operation—by gross sales and acreage. This finding is in keeping with research findings by Oberholtzer et al. (2010), that diverse farms are common in urbanized regions, and by Inwood et al. (2013), that urban area farms tend to have diverse demographics, production systems, and market strategies. The FRAT farms display such diversity.

Access to a diversity of local markets and sources of technical information has been identified as a key area of resilience (Cabell & Oelosfse, 2012; De Schutter, 2014). Expertise in agronomy, entomology, and fungal disease; as well as marketing and farm business management assistance are noticeably lacking in Southwest Washington, especially compared to Oregon and other parts of Washington. Improved access to university research and extension centers and extension specialists, courses, and resources for small farms could be of benefit. All the farmers identified the need for greater consumer awareness and public support. Local efforts to promote marketing and consumer participation in Clark County include those of the Food System Council, existing Farmers' Markets, as well as "food hub" type initiatives and ideas for a year-round market outlet. Many farms market in Portland, where venues are more abundant and/or considered more favorable.

The FRAT was designed to address the following research questions: 1) What are the current and potential areas of vulnerability for food producing farms; and 2) What will be needed to retain and enhance food production capacity for the long term? Further in-depth analysis of assessment data will help determine the usefulness of indicators of agronomic, environmental, economic, and social resilience for food producing farms in urbanizing regions. With a better understanding of farmer perspectives, and the current and potential areas of vulnerability for food producing farms, the intent is to illuminate strategies that serve to support farmers and long-term farming system viability. The data collected for this grant project will be analyzed in more depth for the associated dissertation research project (by co-PI Judith Wait).

VIII. Appendix: Tables of Indicator Scoring Criteria

The tables below for each FRAT realm show the indicators and general scoring criteria. See also the FRAT tables for each realm, with scoring results, above in this report.

Table 5: Agronomic Indicators, Scoring Criteria

A = Agronomic / Farm System		
#	**Indicator**	**General Scoring Criteria** (Score 1 is low; 5 is highest)
A-1	Acres farmed	Scoring was assigned by size range: 1= less than 5 acres; 2= 5-9.99; 3= 10-19.99; 4= 20--99.99; 5= 100 or more
A-2	Access to production land	Adequacy of current land base to meet farm goals (5=plenty… 3=nice idea but not looking…1= need land but barriers exist)
A-3	Integration (types of products)	Number of product types: Vegetables/melons; Fruit/tree nuts; Specialty/herb/flower; Field/seed crops; Other: eggs, meat
A-4	Crop diversity (within product type)	1-3 crops=1; 3-6 crops=2; 7-10 crops=3; 10-15 crops=4; 15+ crops =5
A-5	Varietal diversity (for species of crop)	Number of varieties of top crops produced; same numerical Scoring as above. For example, 1-3 varieties = 1
A-6	Weed management strategies	Number of strategies used. Score also considers low input practices internal to farm (higher score) and use of imports (sheet mulch, straw, chemicals, etc.), which lowers the score.
A-7	Biological control (BC) methods	Number of methods used (hormones, hedgerows, crop inter-planting, succession planting, hand-picking, status quo)
A-8	Practices that Increase biodiversity	Total number of practices used (adopted from (Gliessman, 2014) of the 10 listed:
A-9	Input substance guidance (eg. Organic)	Scored by criteria: 5=chemical free/biological; 4=Certified Organic; 3=organic substances; 2=IMP; 1=conventional chemicals. Adjusted (up) for using more than one strategy.
A-10	Soil testing	1= a test every 5+ years; 2=I test every few years; 3=I test on some fields every two years; 4= annual testing of 1 more fields; 5= test all fields annually
A-11	Innovative Strategies	Number of strategies of 13, Score = 5 for 5 or more

Table 6: Market/Economic Indicators and Scoring Criteria

M = Market/ Economics		
#	**Indicator**	**General Scoring Criteria**
M-1	Gross Sales	Scored by range category, higher sales Scores higher
M-2	Years in business (for the farm)	Number of years, by category: less than 5 =1; 5 > 10 =2; 10 < 15 = 3; between 15 and 20 = 4; more than 20 years in this farm business = 5;
M-3	Value in Land & Buildings	Market value, by category: 1= less than 100,000; 2=$100,000 to $199,999; 3=$200,000 to $499,999; 4=$500,000 to $999,999; 5=$1,000,000 or more
M-4	Land tenure (own, lease)	Very limited tenure via short-term lease=1; mixed or low tenure = 2; partial ownership = 3; owned core plus favorable leased land, or family-owned farm "lease" to young farmer(s)=4; Full ownership of all land=5;
M-5	Post-harvest Capacity	Capacity: 1 = lacking; 2 = barely enough; 3 = OK but want more; 4 = OK adequate; 5= very adequate;
M-6	Diversity of products	Scored by number of other commercial products
M-7	Diversity of markets	Scored by the number of market channels used
M-8	Risks to commercial viability	Scored inversely proportional to the number of risks

Table 7: Environmental Indicator Scoring Criteria

E = Environment		
#	**Indicator**	**General Score Criteria**
E-1	Outside crop area veg. diversity	Criteria after Nicholls (2004), scaled to range from 1="no natural vegetation," to 5 = "surrounded by natural vegetation on at least two sides"
E-2	In crop field area veg. diversity	Criteria after Nicholls (2004), scaled to range from 1=monoculture, to 5= "dense cover crop or weedy background"
E-3	Farmland soil class	Muck, hydric soil =1; Not prime farmland =2; Prime farmland if drained=3; Farmland of statewide importance=4; Prime farmland=5
E-4	Conservation by Irrigation methods	Methods: 1 is hand watering; 2 for soaker hose and/or overhead watering with timer; 3 for dry land farming; 4 if pump control (energy and water efficiency) is used; drip =4 (add 1 for monitoring)
E-5	Water source availability and adequacy	Adequacy of water supply considers farmers' report with additions or deductions: More than 1 source +1; Water right +1; Well OK +2;

Table 8: Social Indicators and Scoring Criteria

S = Social Infrastructure		
#	**Indicator**	**General Scoring Criteria**
S-1	Purpose and goals	Avocation = 1; retirement extra income or sideline business = 2; second career or post retirement business = 3; long term family farm one generation = 4; long term family multi-generation = 5
S-2	Experience in farming	less than 5 years =1; more than 5 but less than 10 = 2; more than 10 = 3 (past "beginning"); more than 30 years = 4 (ie career); Lifelong = 5;
S-3	Participation in groups	Number of groups, associations, or networks
S-4	Information sources accessed	Number of sources used for learning, support, sharing
S-5	Urban neighbor problems	Number of problems identified (or not)

IX. References

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[i] The Resource Centres on Urban Agriculture and Food Security (RUAF). See RUAF Foundation: http://www.ruaf.org/node/512

[ii] Urban Influence Codes for U.S. Counties: http://www.ers.usda.gov/data-products/urban-influence-codes.aspx

[iii] Marco de Evaluación de Sistemas de Manejo Incorporando Indicadores de Sustentabilidad (MESMIS)

[iv] Indicauters de Durabilité des Exploitations Agricoles (IDEA)

[v] http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Washington/

[vi] USDA: Economic Research Service (ERS): http://www.ers.usda.gov/data-products/atlas-of-rural-and small-town-america/go-to-the-atlas.aspx#.UvPfjrS9Lvc

[vii] 52 acres of farmland is now the Erickson Farms residential development (**www.columbian.com** /news/2014/jul/06/erickson-farms-holds-memories-residents-developers/

[viii] Continued road expansion eliminates actively farmed land in the City of Vancouver, making the future of the farm business uncertain. http://www.oregonlive.com/clark-county/index.ssf/2011/12/last_full-scale_farm_in_vancou.html

[ix] "Small Family Farms" gross under $350,000 in the USDA Economic Research Service (ERS) typology (Hoppe & MacDonald, 2014).