1-2021

A cross-cultural, participatory approach for measuring and cultivating resilience on small and medium farms

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A white paper submitted to the University of Vermont Agricultural Research Service Center for Food Systems Research

January, 2021

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Acknowledgements

This paper is the product of a collaborative effort among several valued partners in Puerto Rico and Vermont. These include esteemed colleagues from the University of Vermont (UVM) Rubenstein School of Environment and Natural Resources, UVM Extension, the Vermont Vegetable and Berry Growers Association, Greater Burlington Sustainability Education Network, RCE Puerto Rico-Red de Educación para el Desarrollo Sostenible (REDeS), the Center for Landscape Conservation, and the USDA Caribbean Climate Hub. We are also grateful for the participation of the farmers and their families located in both geographies who participated as partners in this project. Their perspectives, stories and expertise contributed greatly to the co-production of knowledge presented here.

Funding for this work was provided by the Agricultural Research Service Center for Food Systems Research at the University of Vermont.

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Summary

One of the greatest leverage points in fostering the transition to sustainability can be found in the realm of food systems. The COVID-19 pandemic has brought into sharp focus the critical importance of small farm resilience to the well-being of communities around the world. We explored the role of small and medium farms in promoting sustainable social-agricultural systems, and investigated how the resilience of these farms can be both measured and amplified. We integrated concepts from the fields of food systems sustainability and resilience, agroecology, and positive deviance to identify indicators that can help measure and track farm resilience. Our aims were to 1) investigate the diversity of ecological and social factors that impact the vulnerability, resilience, and long-term health of small-medium farms and farm systems, exploring similarities and differences between the two cultures/geographies; 2) incorporate farmers' personal experiences together with knowledge in the academic literature to enrich understanding about food systems sustainability; and 3) develop an indicator tool for evaluating farm resilience that empowers farmers to both assess their local farm system and to implement and document change over time.

Our research process employed a cross-cultural, mixed-methods, Participatory Action Research (PAR) approach that engaged farmers from diverse geographic settings in Puerto Rico and Vermont. The project was organized into four phases implemented over a six month period from July through December 2020. These included identifying farmer participants, selecting key farm resilience frameworks, distilling a preliminary list of indicators, and validating those indicators with farmer feedback through surveys, interviews, and group meetings. The phases culminated in the creation of a **Farm Resilience Tool** for conducting rapid assessments using 20 indicators organized into four categories of Growth Mindset, Strong Relationships, Sustainable Farming Practices, and Sustainable Business Management. We further outlined a proposal for how to implement and refine the tool with farmer participants through subsequent PAR activities. Refinement is essential, given that our proposal is place-based and local, yet also modular and globally scalable to help advance planetary sustainability. More research is necessary to understand potential tradeoffs and synergies that can occur from trying to optimize multiple outcomes in tandem, and how to transition small farm resilience to broader-scale landscape planning and management strategies.

Among the important lessons learned from this project are A) the importance of farmer-to-farmer knowledge sharing, B) the value of an authentic and reciprocal PAR process in expanding the range and depth of understanding beyond the academic literature, C) the utility of integrating positive deviants for helping identify indicators and examples of resilience outside the box of traditional thinking, and D) the rich interaction across cultures and geographies that enlivens the research and enlightens the outcomes. All these lessons converge on the critical insight that sustainability is ultimately about the quality of relationships within food systems. Thus, food systems research must integrate objective and subjective methods in order to cultivate the relational synergy needed to address and transcend the complex problems we face in the 21st Century.

Introduction

As humanity grapples with the intensifying challenges facing life on earth, the 17 Sustainable Development Goals (SDGs) agreed upon by the United Nations provide a compelling blueprint for achieving a just and sustainable future. The pressing and interconnected nature of these challenges – climate change, biodiversity loss, food insecurity – require that the social-ecological systems approach manifested by the SDGs be implemented during the critical decade ahead (Altieri & Nicholls, 2020).

One of the greatest leverage points in fostering the transition to sustainability can be found in the realm of food systems. Small and medium-sized farms offer particular promise in that they often employ innovative and adaptive strategies for building economic, social, and ecological resilience (Berti & Mulligan, 2016; Darnhofer, 2010). Indeed, during the current global pandemic of COVID-19, agribusiness profits are diving (Hart et al., 2020) while community-based agriculture and many small farms are thriving (Westervelt, 2020). What bolsters the resilience of these smaller farms to sustain themselves during times of economic, geo-climatic and socio-political unrest?

Objectives

This white paper describes some key ideas and tools that may help answer that question. It summarizes the process and findings of a research endeavor that explored the role of small and medium farms in promoting sustainable social-agricultural systems, and investigated how the resilience and health of these farms can be both measured and amplified. It is the product of a six-month project supported by the University of Vermont Agricultural Research Service Center for Food Systems Research. The Center seeks to identify the suite of food system metrics, measurement techniques, and/or data integration tools that can measure sustainable outcomes of small and medium farms, their products and supply chains, consumers and broader environmental impact.

Our research process employed a cross-cultural, mixed-methods Participatory Action Research (PAR) (Kindon et al., 2007) approach that engaged farmers from diverse geographic settings in Puerto Rico and Vermont. We integrated concepts from the fields of food systems sustainability and resilience, agroecology, and positive deviance to identify indicators that can help measure and track farm resilience. Previous investigation has focused primarily on the ecological resilience of agroecosystems, with relatively little attention dedicated to understanding the social resilience of the communities that manage those systems (Altieri et. al., 2015). With this in mind, our aims were to 1) investigate the diversity of ecological and social factors that impact the vulnerability, resilience, and long-term health of small-medium farms and farm systems, exploring similarities and differences between the two cultures/geographies; 2) incorporate farmers' personal experiences together with knowledge in the academic literature to enrich understanding about food systems sustainability; and 3) develop an indicator tool for evaluating farm resilience that empowers farmers to both assess their local farm system and to implement and document change over time.

While documenting change is relatively simple, making significant positive change is complex, and may require a farmer's sustained focus, intention, commitment, and energy over multiple seasons. As a result of our research, we propose that lasting improvements in farm system resilience and health require both analytical methods and social synergy; like the two wings of a bird that enable it to fly, resilient, healthy food systems require both elements to get off the ground and be sustained. This vital interdependence entails application of objective and subjective methods involving innovative individuals, as summarized in **Box 1**.

Box 1. Key conceptual methods that guided our approach

Agroecology Principles
Key agroecology principles with diverse **resilience-related analytic methods** provide the essential framework (i.e., the "toolbox") to describe and document change within food systems.

Positive Deviants
Positive deviants are individuals and entities that champion alternative practices and behaviors that generate positive results for improving resilience. They also promote social and behavioral change in others.

Participatory Action Research (PAR)
The PAR approach channels the catalytic energy for farmers to focus, own, and apply sustained effort over time toward realizing sustainability goals in their local communities. PAR also recognizes and honors that context matters -- there is no one set of indicators that will be of equal importance to all farms in all places.

Cross-Cultural Diversity
Cross-cultural diversity (working across difference) can help farmers think outside of the box and envision their role as part of a larger cultural movement aimed at improving the health of the larger food system in which they work. Imagining positive change of one's farm can greatly benefit from external perspectives.

In the following section we build on these foundational ideas, presenting relevant background information about the major frameworks and techniques that informed our work. We then outline and describe our research process and preliminary findings. We conclude with the presentation of an indicator tool and planning process for evaluating farm resilience, and suggest next steps for its application and future investigation.

Background

Definitions

There is a considerable body of literature that offers varying definitions for the terms sustainability and resilience (Marchese et al., 2018; Tendall et al., 2015). For the purposes of this study, we defined **sustainable food systems** according to language used by the United Nations Food and Agriculture Organization (FAO, 2018b, p. 1):

> "A sustainable food system is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised. This means that: it is profitable (economic sustainability); it has broad-based benefits for society (social sustainability); and it has a positive or neutral impact on the natural environment (environmental sustainability)."

Additionally, we defined the terms vulnerability, resilience, and farm health based on descriptions in the literature (**Box 2**).

Box 2. Guiding terms related to farm sustainability

Vulnerability (adapted from Altieri, 2016)
The degree to which the farm system is susceptible to, and unable to cope with or adapt to, adverse effects. It could include the loss of biodiversity, soil and water resources, access to farm inputs and markets, financial support, and labor when confronted with an external perturbation or threats (for example, climate change, Covid-19, or new government policies).

Resilience (adapted from Altieri, 2016; Cabell & Oelofse, 2012)
The capacity of the farm system to retain its structure and function following a perturbation. Resilience can also describe the ability of the farm system to adapt to changing conditions and make adjustments that allow for recovery and transformation. For example, a resilient farm system would be capable of continuing to produce food and remain economically viable when challenged by severe drought or by excess rainfall, a pandemic, political instability, or a loss of markets, etc.

Farm Health (adapted from Müller & Sukhdev, 2018; Tendall et al., 2015)
Farm health describes the holistic resilience of the farm over time, and the ability to maintain its organization and thrive even with ongoing vulnerability stressors. The level of health is dependent on environmental elements of soil fertility, water quality, and biodiversity that affect plants, livestock and human health, economic viability, as well as social qualities of family and community relationships that together sustain the farm, build capacities, and promote well-being.

Agroecology

Agroecology is a transdisciplinary approach that integrates ecological science with other academic disciplines, as well as non-academic, traditional, local knowledge systems, to challenge the current global agrifood system and guide research and actions towards its sustainable transformation (UVM-ALC, 2020). In practice, agroecology can also express itself as a social movement that presents an alternative to address the interrelated ecologic, economic, social, and cultural crises that have emerged as a result of modern, extractive, industrial agriculture (Altieri, 1995).

The principles of agroecology (CIDSE, 2018) (**Appendix I**) align directly with several of the SDGs (Altieri & Nicholls, 2020; FAO, 2018a; Millennium Institute, 2018), including Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture; Goal 10: Reduce inequality within and among countries; and Goal 13: Take urgent action to combat climate change and its impacts. Leippert et al. (2020) provide links and scientific evidence on how agroecology has the potential to build climate-resilient food systems and livelihoods that contribute to sustainability. They assert that agroecology "is key for its true transformational power" as a transdisciplinary field that rests on systemic thinking, builds on ecological principles, nurtures local knowledge and participatory governance, and advances crucial social justice aspects (Leippert et al., 2020, p. xiii; Méndez et al., 2015). Miguel Altieri, a well-known scholar in the field of agroecology writes that, "When applying agroecological principles farmers and their farming systems can respond creatively and adaptively to environmental change. Depending on the socioeconomic,

cultural and environmental realities of each community, these principles take different technological forms and are applied as a set of practices" (Altieri, 2016, p. 14).

A key insight of the agroecological vision is that context matters. Although there are general guiding principles with universal relevance, their effective implementation must be context specific, and invariably lead to differential outcomes in different places that appreciate the contextuality of experience (Bell & Bellon, 2018). Thus, in agroecology there is no one size fits all, which contrasts directly with the simplification and homogenization of industrial food systems. Knowledge-based, participatory approaches are championed by agroecology advocates to understand the complex and spatio-temporal dynamics of local agri-food systems and develop multifunctional, adaptive management responses appropriate to local conditions and resources (Thomson & Scoones, 2009).

Positive Deviance

Where can we find concrete examples of resilience in food systems? A great place to start is to look within existing farmer networks. Using an approach developed in the field of public health known as Positive Deviance (PD), it is possible to identify farms that are thriving even in the midst of challenging environmental and social conditions. According to Sternin (2003): "Positive Deviance is based on the belief that in every community there are certain individuals/entities whose special practices or strategies enable them to find a better solution to a pervasive problem than their neighbors who have access to exactly the same resources. We call these individuals *positive deviants*". The PD approach enables the discovery within communities of uncommon yet demonstrably successful practices that manifest resilience. Researchers can work directly with these positive deviants to investigate their practices, and facilitate opportunities for them to engage directly with other members of the community (Sternin, 2003). In other words, the PD approach encourages robust farmer-to-farmer exchange and sets the stage for resilience to spread through the farming community.

Participatory Action Research

In recent decades, PAR has emerged as a legitimate approach for engaging with a diversity of actors, including positive deviants, to investigate resilience of agroecological systems (Méndez et al., 2017). PAR is a collaborative approach to knowledge creation that incorporates inclusive participation of stakeholders in the research process, with the aim of encouraging critical, actionable knowledge that can lead to behavioral change and ultimately policy reforms. At its core, PAR is iterative and flexible, interweaving research, reflection and action, and theory and practice to empower participants and find practical solutions to problematic situations (Cornwall & Jewkes 1995; Kindon et al., 2007). With a focus on stakeholder-defined priorities and perspectives, PAR converges local knowledge and expertise with academic theories and methods. Notably, researchers are not passive, value-neutral observers or experimenters, but active participants in the process. In this way, PAR can produce more comprehensive knowledge that includes the complexity of subjective value positions inherent to social interactions (Bacon et al., 2005). By respecting a diversity of opinions, especially the voices of those who are often marginalized, PAR can also facilitate

spaces of dialogue to deal with complex multi-sectorial and multilevel socio-ecological challenges (Burns et al., 2012; Méndez et al., 2013).

PAR has been utilized to gain insight into alternative food systems and agroecological practices precisely because it offers a transdisciplinary approach for engaging smallholder farmers in the inquiry process and integrating their knowledge of place and farming practices into the learning cycle to generate practical solutions (Méndez et al., 2013). Several studies have documented the intersection of PAR with agroecology, including analysis of strategies for supporting biodiversity conservation and household livelihood strategies of coffee farmers in El Salvador (Méndez et al., 2010), alleviating food insecurity and strengthening sustainable local food systems in Nicaragua (Bacon et al., 2014) and Mexico (Putnam et al., 2013), and assessing agroecological management as a contribution to rural households affected by HIV/AIDs in Malawi (Nyantakyi-Frimpong et al., 2016). Prior review of PAR agroecological processes suggests that an integrated approach has great potential to support a transformation towards more sustainable agrifood systems (Levidow et al., 2014; Mendéz et al., 2017).

Cross-cultural, Mixed Methods Approach

Many PAR applications embody systems thinking as a means of understanding the relationships, feedbacks, and emergent properties of complex social-ecological systems (Bland & Bell, 2007). Systems thinking recognizes the importance of non-linearity and context-specific approaches (Ison, 2008). The process of knowledge inquiry typically incorporates a mix of quantitative and qualitative methods to engage with non-academic groups in different socio-cultural contexts, allowing for examination of complex social phenomena from objective and subjective perspectives (Creswell & Clark, 2017). This can help address questions that both verify and generate knowledge, and lead to more comprehensive and applicable solutions (Tashakkori & Teddlie, 2009).

Furthermore, there is value in conducting PAR simultaneously across multiple geographies and cultures. Combining knowledge and tools from different socio-cultural traditions and locations can illuminate novel understanding about resilient and sustainable food systems from distinct perspectives (Anderson et al., 2017). Cross-cultural research also provides opportunities for meaningful comparisons that can reveal differences across scales of social organization (Tung, 2008), why those differences occur and how they change over time (Matsumoto & Yoo, 2006). The resulting knowledge provides a robust foundation on which to construct hybrid methodologies for tailoring and transferring that knowledge into local policy and action.

Having presented these definitions and frameworks, we now turn to a detailed discussion of the methods we employed to carry out our research.

Methods & Preliminary Findings

Research Process and Phases

The project was organized into four main phases that built on each other in an iterative fashion and were implemented over a six month period from July through December 2020 (**Figure 1**). Each phase included one or more steps and resulted in preliminary findings that contributed to the development of an indicator tool for assessing farm resilience. Below we present the details and findings of each phase, and how they were used to inform the next steps in the research process.

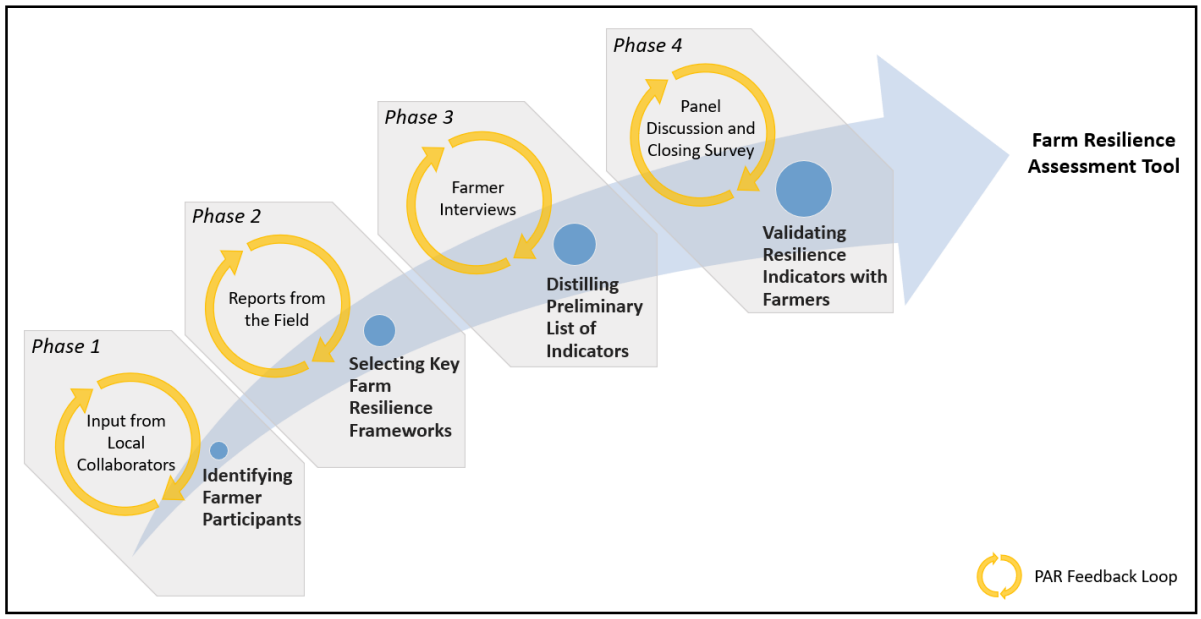

Figure 1. Research process showing four main phases (blue circles) and ongoing PAR interactions (orange loops). See text for additional explanation.

Phase 1: Identifying Farmer Participants

Step 1. Network Collaboration

Methods & Preliminary Findings

To identify farmers in Puerto Rico and Vermont, we sought guidance from members of Regional Centres of Expertise (RCE) on Education for Sustainable Development located in the two geographies. The RCEs in Vermont and Puerto Rico are closely aligned in the pursuit of knowledge about healthy, resilient food systems, and strong relationships have developed over the past decade. Organizations in both places are focused on promoting sustainable social-ecological systems at the watershed scale, where local food production and community vitality are valued alongside the restoration of water quality, biodiversity, and soil productivity.

In Puerto Rico we collaborated with the Center for Landscape Conservation and the USDA Caribbean Climate Hub in Puerto Rico, whose contacts include a wide network of

stakeholders, including farmers, ranchers, landowners, research and extension specialists, and natural resource managers in Puerto Rico and the US Virgin Islands. In Vermont, we partnered with scholars at the University of Vermont (UVM) Rubenstein School of Environment and Natural Resources, and UVM Extension, and the Vermont Vegetable and Berry Growers Association, which consists of large and small scale commercial growers, industry representatives, university specialists, and agricultural management personnel. These collaborators were instrumental in helping identify and contacting focal farms and "positive deviant" growers.

We initially proposed involving 12 farms in the project, six each from Puerto Rico and Vermont. Our research team took a subjective approach (i.e., no randomized sampling was conducted), seeking to include "positive deviants" farmers who are implementing innovative practices and strategies. We also considered several criteria for participation (**Box 3**). Approximately 30 farms were identified in Puerto Rico and 284 farms in Vermont.

Box 3. Criteria for farmer participation (in addition to being considered "positive deviants")

- Farms with a mixed crop farming process (within individual farms), although dominance of a principal crop or product was also accepted.
- Farms with a diversity of crops and products (among different farms), including vegetables, meat, biomass, fish, among others.
- Farmers who actively practice agroecological and sustainability principles in their farm system, or are open to doing so.
- Farmers for whom their dominant income (at least 50%) comes from their agricultural products. The income could be from marketing their products either unprocessed or processed for added value. The marketing of the products could be done directly or by cooperatives or supporting groups.
- Farmers could be either owners or renters of the land used for the farming activities.

Step 2. Farmer Outreach

Methods

Next, we conducted outreach directly with the candidate farmers in both geographies via emails. In Puerto Rico we communicated in Spanish while in Vermont we used English. In those communications we included the list of criteria, and presented a calendar of activities that would play out over the next several months following their acceptance, with a total anticipated time investment of approximately ten hours per farmer. We also offered farmers an incentive of $500 for participating as co-researchers in the project. Many farmers expressed interest and we followed up with them via phone calls and in some cases in-person visits, honing the list of candidates to about fifteen in each geography. Some farmers decided not to participate because of time limitations and other conflicts, or reduced agricultural production.

The final list included 14 farms in total, six in Puerto Rico and eight in Vermont. The participants signed a formal letter of agreement (approved by the Institutional Review Board at the University of Vermont) outlining their participation in the project and the monetary

incentive. We inquired of farmers about basic demographic information regarding the size of their farm, principal crops and products, number of years farming, number of persons working on the farm in full and part-time capacities, and the number of family members involved in the farming process. We did not ask for personal information regarding production numbers and income.

Preliminary Findings

The names and locations of the farms that participated in the project can be viewed via this Google Map. Farms ranged in size from one to 357 acres (**Table 1**). Land tenure included both owners and renters. Production included a variety of crops and products such as mixed greens, root vegetables, ornamental flowers, medicinal plants, herbs and spices, berries, fruit trees (e.g., guava, avocado, papaya, bananas, cacao, citrus), coffee, honey, Christmas trees, livestock (e.g., dairy cattle and goats), poultry, and fish (farm raised and wild caught).

Table 1. Summary demographics of 14 farms in Puerto Rico and Vermont.

	PUERTO RICO (n=6)		VERMONT (n=8)	
Variable	Range	Average	Range	Average
Farm size (acres)	1 - 182	37	12 - 357	157
Years farming on land	6 - 16	10	4 - 47	13.5
Projected future years farming on land	15 - 40	25	20 - 35	29
Number of family members working on farm	1.5 - 6	3	2 - 4	3.3
Number of non-family employees	0 - 5	3	0.5 - 40	9

Phase 2: Selecting Key Farm Resilience Frameworks

Step 1. Reports from the Field

Methods

To get an initial idea of the overall status of each farm, we asked each farmer to complete a Report from the Field (**Appendix II**). This short survey (created using Google Forms; separate forms with similar content in Spanish and English) was designed to take the pulse of their farm during the current growing season (from March to September 2020, when the survey was conducted). The survey focused on eight "context areas" relevant to the overarching conceptual frameworks of sustainable food systems and agroecology. These were: Farm Vulnerability, Natural Resources, Human Capital, Farm Work, Processes and Institutions, Markets, Financial, and Personal. See Appendix II for definitions of these terms.

Farmers ranked their attitudes and perceptions from 1 to 5 on a Likert scale, choosing one rank per context area that best described their feeling for that category, weighing positive and negative attributes. The rankings were: *1--bad/couldn't be worse*; *2--could be better*; *3--doing OK...on balance neutral*; *4--doing well*; and *5--great/can't get any better*. We also asked farmers to rank their overall attitude for all eight areas combined, using the same scale.

Following completion of the Reports from the Field, we hosted a virtual two-hour group meeting for all participants using Zoom video conferencing technology. During the discussion, we reiterated the project goals and timeline, the farmers introduced themselves and described their farms, and we discussed their responses to the Reports from the Field. The panel discussion was conducted in both English and Spanish, with translations occurring in real-time for better exchange between participants. The meeting was also recorded.

Preliminary Findings

The Reports from the Field helped affirm that we had indeed selected farmers who aligned with our search for positive deviance, and established an important baseline about specific themes and issues that resonated with them. For example, farmers in both Puerto Rico and Vermont indicated room for improvement in all context areas, with overall combined rankings falling roughly in the middle of the scale (**Figure 2**). While the purpose was not to do a formal analysis comparing Puerto Rico and Vermont, there were some interesting differences in rankings. Follow-up conversation in the virtual meeting provided insight into some of the underlying factors that influence farm vulnerability and resilience at local scales, such as climate and weather-related phenomena, access to financial resources, and the value of family and community relationships. Moreover, this interpersonal interaction served as an important "preflection" phase of the PAR process (Méndez et al., 2017, p. 2), in which our research team and the farmers were able to get to know each other, learn about the project's priorities and expectations (for both farmers and researchers), prepare and plan for next steps, and, most importantly, to build trust.

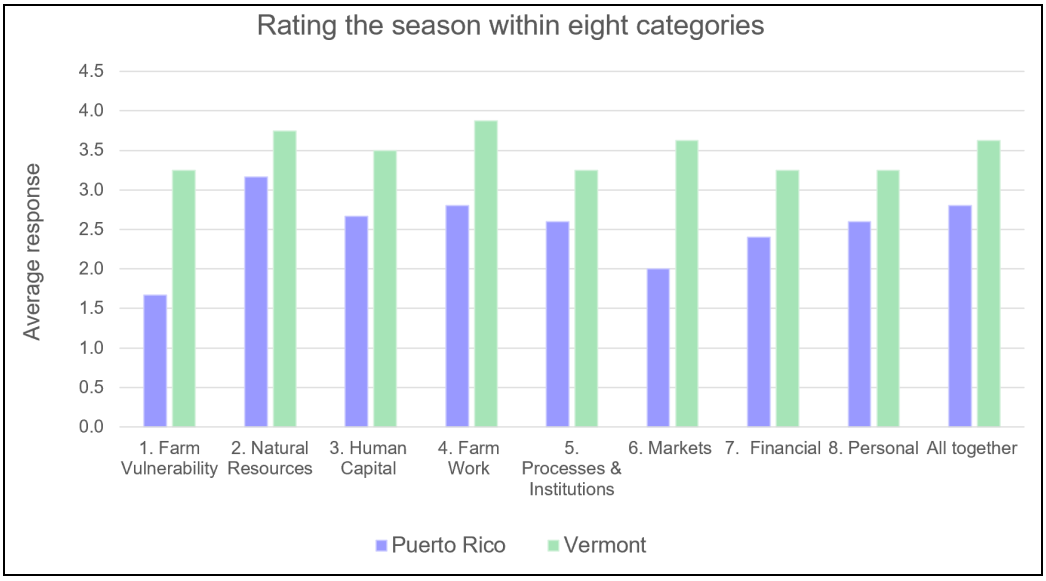

Figure 2. Average responses for Reports from the Field from 14 farms in Puerto Rico and Vermont, regarding eight individual context areas and all areas combined.

Step 2. Review of Indicator Frameworks

Methods

Feedback from the farmers in Step 1 offered a valuable lens through which to view the literature on farm resilience indicator frameworks. Subsequently, we conducted a narrative literature review of frameworks related to resilience in sustainable agri-food systems using prominent online, academic search engines (e.g., Google Scholar, ScholarWorks@UVM). The search criteria included:

- Peer-reviewed research articles published fairly recently (i.e., in the 21st century).
- Reports and documents written by government agencies and well-known non-governmental organizations.
- Books and other non-peer-reviewed literature produced by well-known authors on the topics of principles, indicators, frameworks or metrics for resilience in sustainable farming, agroecology and local agri-food systems.

Preliminary Findings

This initial online literature search revealed thirty-two potential sources for background information. From these, we refined the list to 15 sources for a more in-depth evaluation as possible examples of frameworks based on our research goals and questions. Reflecting on farmer feedback from the Reports from the Field and the first group meeting, we distilled the list further to six key sources to underpin our research framework (**Table 2**).

Altieri (2016) provides a set of ten resilience principles that he connects with his fundamental principles of agroecology, as well as examples of assessment-related questions and indicators to determine the vulnerability and response capacity of farmers. His resilience principles are similar to the indicators proposed by Tittonell (2020) and Cabell and Oelofse (2012). Altieri also highlights the importance of traditional farming systems as models of agroecosystem resilience. Moreover, Altieri (2016), Altieri et al. (2015), and Koohafkan et al. (2012) provide frameworks with essential attributes agricultural systems must have to reduce their vulnerability and enhance resilience in the face of extreme climatic threats. In Koohafkan et al. (2012), the attributes are similar and framed with goals for green (sustainable) agricultural systems. IPES-Food (2016) provides a list of eight lock-ins for agroecological-related changes in a system that may increase vulnerability and reduce resilience. These lock-ins are also points of intervention that can inform the development of indicators and metrics for resilience and sustainability-related changes in food systems. Cabell and Oelofse (2012) proposed 13 comprehensive behavioral-based indicators for resilient systems adapted by Tittonell (2020). As Cabell and Oelofse (2012, p. 9-10) posit:

> "…despite the attempts of many, measuring resilience in socio-ecological systems has proven to be like aiming at a moving target. We agree with those who advocate for developing less precise rules of thumb and, in that vein, have compiled an index of behavior-based indicators of resilience in the agroecosystem. These indicators identify behaviors that, when present, imply that the system is more capable of persisting in its ability to meet the food, fuel, and fiber needs of humans well into the future. Absence or disappearance of these behaviors signals vulnerability in the agroecosystem and a need for intervention."

Table 2. Principal literature identified as sources of information for farm resilience indicator frameworks.

Key references	Brief description of content
1. Altieri (2016)	Provides a set of ten principles of resilience, somewhat similar to Tittonell's indicators: (1) diversity, (2) redundancy, (3) decentralization, (4) collaboration, (5) flexibility, (6) heterogeneity, (7) autonomy, (8) adaptability, (9) foresight, and (10) regeneration.
2. Altieri et al. (2015)	Provides a set of agroecosystem features that enhance resilience and reduce vulnerability in the face of climatic threats: vegetation diversity (i.e., agroforestry systems, polycultures, genetic diversity, animal integration) and soil and water management (i.e., organic matter, soil cover, and water harvesting), both supporting a complex landscape matrix or heterogeneity. Altieri (2016) also explains and uses these features to develop a set of indicators for farm ecosystem.
3. Cabell & Oelofse (2012)	Provides thirteen behavioral-based indicators for resilient systems that are adapted by Tittonell (2020). These are: (1) socially-self organized, (2) ecologically self-regulated, (3) appropriately connected, (4) functional and responsive diversity, (5) optimally redundant, (6) spatial and temporal heterogeneity, (7) exposure to disturbance, (8) coupled with local and natural capital, (9) reflective and shared learning, (10) globally autonomous and locally interdependent, (11) honors legacy, (12) builds human capital, and (13) reasonably profitable.
4. IPES-Food (2016)	Proposes eight lock-ins that may increase vulnerability and reduce resilience in agri-food systems: (1) short-term thinking, (2) compartmentalized thinking, (3) concentration of power, (4) export orientation, (5) path dependency, (6) measures of success, (7) expectation of cheap food, and (8) feed the world narratives.
5. Koohafkan et al. (2012)	Similar proposal as Altieri (2016) and Altieri et al. (2015) framed under attributes and goals for sustainable (or green) agricultural systems. Includes a set of guiding questions to assess if agricultural systems are contributing to sustainable livelihoods. Uses the Evaluation of Natural Resource Management Systems (MESMIS) as reference with specific parameters.
6. Tittonell (2020)	Provides a comprehensive list of ten indicators for the resilience of agroecosystems, adapted from Cabell and Oelofse (2012): (1) self-regulation, (2) connectivity, (3) functional diversity and redundancy, (4) response diversity, (5) space and time heterogeneity, (6) building of natural capital, (7) social self-organized, (8) reflective learning and human capital, (9) autonomy and local interdependency, (10) and capitalizing local knowledge.

Tittonell's (2020) framework focuses on assessing the resilience and adaptability of human-mediated agroecological transitions. Under the complex adaptive cycle conceptual model (Holling's Adaptive Cycle) of long-term change dynamics in socio-ecological systems, Tittonell associates and adapts ten resilience indicators proposed by Cabell and Oelofse (2012) to the complex adaptive cycle.

With their proposed principles, lock-ins, and indicators, the above-selected sources furnished the vocabulary, topics, and categories underpinning the next phase of our research. They provided the foundation of our guiding questions for the interviews with the farmers. Moreover, they helped us to focus our search for meanings and relationships while coding for content and thematic analyses of the data collected in those interviews.

Phase 3: Distilling Preliminary List of Indicators

Step 1: Farmer Interviews

Methods

We conducted individual interviews with the farmers in order to learn about the farmers' unique perspectives on long-term sustainability and resilience of their local farm system. In these interviews, we inquired about the challenges they face, what steps have been taken to adapt, survive and succeed during difficult times, the nature and quality of relationships with key stakeholders, and their aspirations for the future.

In preparation for the interviews, we presented the farmers with clear definitions of the terms Vulnerability, Resilience, and Farm Health, and how they relate to sustainability, as described earlier. Each interview lasted approximately 1.5 to 2 hrs and included several semi-structured questions (**Appendix III**) that were used as an informal guide. The interviews were conducted virtually in Spanish and English via Zoom, and were recorded. The fourteen interviews were transcribed by the University of Vermont Captioning Office, including six that were first translated from Spanish to English.

Using NVivo 12 Pro Windows software, we conducted qualitative coding of the transcripts to organize the data collected and link it to our research questions. The qualitative coding process used content and thematic analysis strategies to facilitate the meaningful categorization and synthesis of the data collected to find patterns, frequency, and relationships (Vaismoradi et al., 2013) in the farmers' narratives. Content and thematic analyses also helped identify convergent and divergent practices and concerns expressed by the farmers. Furthermore, we used a structural coding method (Saldaña, 2016) to organize the data into smaller, manageable units. These smaller units were extracted from the three main factors that guided the semi-structured interviews (i.e., questions about the farmers' vulnerabilities, resilience, and vision of a healthy farm system). Using these smaller units to facilitate coding and the content and thematic analysis process, we were able to identify and compare common threads as well as the prevalence of thematic patterns to contextualize the farmers' experiences around our topics of research interest (Bazeley & Jackson, 2013; DeSantis & Ugarriza, 2000; Elliot, 2018; Saldaña, 2016; Vaismoradi et al., 2013).

Through a recursive thinking process, some of the codes were merged or re-clustered to facilitate a concise and clear visualization of the result based on our research questions. The coding process also involved a combination of deductive and inductive reasoning – deductive when the codes were directly related to the responses of the farmers to our guiding questions; inductive when new topics emerged that were not directly related to the questions – but were considered important to enrich and substantiate our findings (e.g., unique contextualized expressions, practices, or concerns).

Preliminary Findings

The synthesized findings of the farm interview coding process are shown in **Table 3**. In this initial qualitative phase, we categorized the results to facilitate understanding in four main categories (some additional topics of interest were categorized as "others"):

- *attitude* (when the information coded from the interviews related to the farmers' mindset);
- *relationships/networks* (coded information related to their family, community and business relationships or networks);
- *sustainable practices* (coded information regarding their actual on-farm sustainable practices) with sub-codes (specific practices) that scored higher (**Table 4**); and
- *key business skills and economic leeway* (coded information regarding their farm financial and business aspects).

Table 3. Results of the coding of farmer interviews with NVivo 12 Pro Windows. References are the number of times a code was assigned to contents or passages in the different interviews.

attitude	relationships/ networks	sustainable practices	key business mng. skills and economic leeway	others

Description	Files (# farms)	References
positive mindset _ entrepreneurial / *mentalidad positiva_ empresarial*	14	96
flexible to changes / *flexible ante los cambios*	14	65
community ties + familly support / *vínculo con la comunidad + apoyo de la familia*	13	83
sustainable farming practices _ agroecosystem conservation / *practicas agrícolas sostenibles _ conservación del agroecosistema*	13	47
dependable business networks (food system) / *redes confiables de negocio (sistema alimentario)*	12	88
planning and monitoring / *planificación y seguimiento*	12	29
reliable crew / *personal confiable*	11	35
diversification of markets and venues/ *diversificación del mercado y vías de venta*	11	34
learning from past experiences / *aprendizaje de experiencias pasadas*	11	28
passion for farming/ *pasión por la agricultura*	10	22
interest in learning,/ *interés en aprender*	9	31
focusing on recurrent customers / *enfoque en clientes recurrentes*	9	20
appropriate technologies and infrastructure for the farm / *tecnologías e infraestructura apropiadas para la finca*	9	19
size of the farm (smallholders, family) farm / *tamaño de la finca (pequeños agricultores, familiar)*	9	15
off-farm income / *ingreso adicional no relacionado a la finca*	8	11
financial leeway, capacity /*margen financiero, capacidad económica*	8	18
staying tuned with the market / *mantenerse en sintonía con el mercado*	7	15
balance work, family, farm / *balance entre trabajo, familia, finca*	7	13
online sales, services and connections / *venta y servicios en línea y conexiones*	7	8

The results of the interviews showed that attitude (especially general positive mindset and flexibility) and relationships or networks (strong community, family and business relationships) have a high priority for the resilience and long-term sustainability of the farmers interviewed, both in Puerto Rico and Vermont. Under the agroecology-related literature for farming systems, this finding concurs with Altieri et al.'s (2015, p. 15) statement that, "The capacity of farmers to adapt is based on the individual or collective reserves of human and social capital that include attributes such as traditional knowledge and skills, levels of social organization, and safety networks, etc." Other important topics are particular sustainable farming practices (e.g., agroecosystem and soil protection or restoration, diversification of crops and products, and reduced dependence on external input), and key business-related matters (e.g., planning and monitoring, having a reliable crew, and diversification of markets and venues).

Table 4. Results of the coding related to sustainable practices using NVivo 12 Pro Windows. References are the number of times a code was assigned to contents or passages in the different interviews.

sustainable practices

Description	Files (# farms)	References
sustainable farming practices _ agroecosystem conservation / *practicas agrícolas sostenibles _ conservación del agroecosistemas*	13	47
• agroecosystem protection, restoration / *protección del agroecosistema, restauración*	10	18
• soil protection, restoration / *protección del suelo, restauración*	9	17
• diversification of crops, products / *diversificación de cosecha, productos*	8	16
• reduced dependence on external inputs / *reducción en la dependencia de insumos externos*	5	11

Even though our focus while coding was on finding the strengths of the farmers as positive deviants for resilience and long-term farm system health, the interviews revealed some common concerns and vulnerabilities. Some of these vulnerabilities mirrored the results already highlighted in Table 3, but there were some additional mentions such as government (related to the lock-ins by IPES-Food, 2016) and water. These issues were mostly related to the slow response of the government in times of crises (e.g., COVID-19, climate-related disasters) and water management and accessibility in times of drought, which can greatly influence their resilience.

Step 2: Preliminary List of Resilience Indicators

Methods

The results from the coding and analysis of farmer interviews demonstrated that there were numerous resilience related practices, behaviors and vulnerabilities (codes) commonly mentioned by both PR and VT farmers. When comparing these results with the key indicator frameworks we selected (Table 2), we found that there is much overlap between our findings and what has been suggested in the literature.

However, we also found some additional insights that surfaced from our participatory approach that were not as predominant in other frameworks (such as the increased value of attitude and positive mindset for resilience). Using our collective knowledge as well as the revised indicator frameworks, we reviewed each code carefully to refine its language and definition, so it would be better understood by farmers for subsequent feedback. We also revised the language in our initial code categories to ensure a better fit with the language that is used in the sustainability and resilience literature.

Preliminary Findings

Through this conceptual and analytical revision of the coding results, we arrived at a preliminary list of 20 resilience indicators, organized in four categories (**Figure 3**). These indicators represent factors that, if improved, would result in increased farm system resilience, where the farm is expected to be more capable of coping and adapting to shocks and uncertainties.

GROWTH MINDSET	SUSTAINABLE FARMING PRACTICES
Open attitude Flexible Interest in learning Passion for farming	Build healthy soil Protect natural resources and biodiversity Diversify farm products Minimize external inputs Water-use efficiency
STRONG RELATIONSHIPS	**SUSTAINABLE BUSINESS MANAGEMENT**
Dependable business networks Community ties Reliable crew Family support Responsive government	Effective planning and monitoring Cultivating a healthy workplace Diversifying markets and venues Financial leeway and capacity Appropriate equipment and infrastructure Focusing on recurrent customers

Figure 3. Preliminary list of indicators (organized in four categories) that were presented to farmers for feedback.

Phase 4: Validating Resilience Indicators with Farmers

Step 1. Follow-up Panel Discussion

Methods

An integral component of the PAR process is to share back the research findings with community stakeholders who participate as co-producers of knowledge (Méndez et al., 2017). To accomplish this, we conducted a 2.5 hr follow up panel discussion (virtual, through Zoom) with as many of the farmers and members of the research team as were able to attend. This panel fulfilled various purposes: 1) to present a summary of the project to date, including a recap of our main goals, our methods and workflow, preliminary results to date and next steps; 2) solicit feedback from farmers on our process and preliminary list of resilience indicators; and 3) provide a space for the farmers to share a meaningful picture and some thoughts about their farm's resilience, vulnerability and/or health. The panel discussion was conducted in both English and Spanish, with translations occurring in the moment for better exchange between participants, and was recorded so that it could be shared with those who were not able to attend.

Preliminary Findings

The panel discussion provided a space for open and transparent sharing between the research team and the participating farmers. After the presentation of the project summary and preliminary results, some of the farmers had specific questions about the interview coding process and commented on the importance of a few of the indicators. But all in all, they seemed to understand and agree with our process and did not have specific recommendations that would cause a change in our approach or preliminary findings. This helped demonstrate how we considered their feedback into our findings and served as validation of our research process.

Sharing farm photos and stories energized and brought personality and meaning into our closing meeting. The scope of challenges and opportunities across disparate geographic areas was manifested in the exhibited photos and accompanying comments. Seeing "day-in-the-life" issues of different farms was one of the primary reasons for including farmers as project collaborators, and photo sharing literally gave voice to those personal perspectives. The following two quotes from farmers in Vermont and Puerto Rico illustrate the strength of relationships that was palpable among all farmer participants:

> *"We chose this photo because the resilience of our farm is really based in our family. Our family is so important….It's why we're choosing to do the work that we do. I think that the land is just so resilient on its own, and it's choosing to work with rather than against that resiliency, that forms the basis of the idea behind why we do what we do."*
>
> *--Vermont farmer*

> *"This picture shows our tilapia rescue mission after the hurricane. We picked up whatever fish we found lying around the farm, put them on that slide, and slid them down to the pond to... try to save them. That's a resilient response with all the family, so I am pointing out the importance of our family here."*
>
> *--Puerto Rico farmer*

Step 2. Closing Survey

Methods

Through the interview coding process (Phase 3), we came up with a preliminary list of 20 indicators for assessing farm system resilience. Instead of considering this list as final, we were interested in determining the relevance and validity of these indicators with the farmers themselves (de Olde et al. 2017a). We developed a closing survey (**Appendix IV**) to solicit feedback on our findings and inform the selection of final indicators to be included in the resilience assessment tool. We also saw this survey as an opportunity to inquire about the farmers' perspectives on the project and what they learned, and obtain recommendations for enhancing the level of collaboration between researchers and farmers.

The closing survey was offered after our panel discussion in both English and Spanish. We included two ways to rank the indicators, to ensure a better understanding of their importance. First, we asked farmers to rate each indicator in terms of their importance for increasing the resilience and health of their farm. There were four possible answers for each indicator: not important, slightly important, important, or very important. All indicators were accompanied by appropriate examples, to ensure all farmers understood what each indicator represented. Then, we asked farmers to select the three indicators that they considered most important for their resilience. Lastly, we asked farmers to answer a few open questions related to what they learned throughout the project and how we could improve our collaborative process in the future.

Preliminary Findings

The results of the survey show that, for both regions, none of the indicators were considered 'not important' for resilience (**Table 5**). They were all considered to be important at some level, which helps confirm that our interview analysis process was successful and validates our findings. Of all indicators, only 'build healthy soil' and 'dependable business networks' were voted as very important by all farmers, while 'responsive government' ended up in the last place with only 50% of votes as very important. When looking at overall indicator categories, we were surprised to find that Growth Mindset indicators were rated as very important by most farmers, while Sustainable Farming Practices were not as important as expected.

Table 5. Rating of resilience indicators by level of importance for farm resilience (all farms, n=14). Orange = Growth Mindset indicators, Blue = Strong Relationships indicators, Green = Sustainable Farming Practices indicators, Purple = Sustainable Business Management indicators.

Order of importance	Resilience Indicators	Very important	Important	Slightly important	Not important
1	Build healthy soil	100%	0%	0%	0%
2	Dependable business networks	100%	0%	0%	0%
3	Passion for farming	93%	7%	0%	0%
4	Cultivating a healthy workplace	93%	0%	7%	0%
5	Flexible	86%	14%	0%	0%
6	Interest in learning	86%	14%	0%	0%
7	Community ties	86%	14%	0%	0%
8	Open attitude	79%	21%	0%	0%
9	Reliable crew	79%	21%	0%	0%
10	Effective planning and monitoring	79%	21%	0%	0%
11	Financial leeway and capacity	71%	21%	7%	0%
12	Diversifying markets and venues	71%	14%	14%	0%
13	Focusing on recurrent customers	71%	7%	21%	0%
14	Family support	64%	36%	0%	0%
15	Diversify farm products	64%	36%	0%	0%
16	Appropriate equipment and infrastructure	64%	29%	7%	0%
17	Protect natural resources and biodiversity	57%	36%	7%	0%
18	Water-use efficiency	57%	36%	7%	0%
19	Minimize external inputs	57%	29%	14%	0%
20	Responsive government	50%	21%	29%	0%

For a more rigorous ranking of the proposed indicators, we evaluated the results from the farmers' top three choices of indicators that most relate to their resilience. This resulted in 'build healthy soil' as the most important indicator (voted on by 43% of farmers), while there were zero votes for 'responsive government', 'interest in learning', and 'focusing on recurrent customers' (**Table 6**). It was interesting to observe how the order of importance varied when the farmers were explicitly asked to make decisions about which indicators to prioritize. For example, 'protecting natural resources and biodiversity' moved from position #17 to position #9, while 'cultivating a healthy workplace' moved from position #4 to position #15. This reveals some of the tradeoffs that could occur when farmers are required

to prioritize some efforts over others in an attempt to increase their resilience. More research is necessary to understand these tradeoffs and also the synergies that can occur from trying to optimize, agricultural, ecological, and socio-economic outcomes in tandem, and inform effective decision making (Kanter et al., 2018).

Table 6. Ranking of resilience indicators by top three most important for farm resilience (all farms, n=14). Orange = Growth Mindset indicators, Blue = Strong Relationships indicators, Green = Sustainable Farming Practices indicators, Purple = Sustainable Business Management indicators.

Order of importance	Resilience Indicators	Farm votes
1	Build healthy soil	43%
2	Flexible	36%
3	Passion for farming	29%
4	Community ties	29%
5	Family support	29%
6	Financial leeway and capacity	21%
7	Open attitude	14%
8	Reliable crew	14%
9	Protect natural resources and biodiversity	14%
10	Water-use efficiency	14%
11	Effective planning and monitoring	14%
12	Dependable business networks	7%
13	Diversify farm products	7%
14	Minimize external inputs	7%
15	Cultivating a healthy workplace	7%
16	Diversifying markets and venues	7%
17	Appropriate equipment and infrastructure	7%
18	Interest in learning	0%
19	Responsive government	0%
20	Focusing on recurrent customers	0%

Since all 20 proposed indicators were considered at least slightly important (and for some individuals very important) for resilience by farmers in both Puerto Rico and Vermont, we decided to include them all in the assessment tool. None of the farmers recommended any additional indicators that should be considered, and some even commented that the list was very complete. However, if shortening the list is needed in the future, we recommend reviewing the order of importance in Table 6 to decide which indicators to eliminate, or repeating the same ranking exercise with a higher number of farmers across various geographies.

This closing survey also served to demonstrate how valuable our collaborative and participatory research project was for promoting shared learning and reflection among farmers. We expand on some of the ideas that emerged in the Lessons Learned section below.

Results

Farm resilience against stressors, unexpected shocks and future uncertainties is an integral component of food system sustainability (Tendall et al., 2015). We developed a resilience assessment indicator tool based on the iterative process of integrating relevant literature together with farmer feedback, as discussed in previous sections of this paper. This tool serves to measure and track farm resilience across geographies and cultural divides through the use of a PAR approach. This would allow the Food Systems Center to establish long-lasting collaborative relationships with participating farmers, in a way that allows both the gathering of data as well as monitoring farm resilience over time.

Farm Resilience Assessment Tool

Numerous tools have been developed for assessing farm system sustainability (of which resilience is a key component), and they can widely vary in scope, assumptions, selection of indicators, valuation method, and overall applicability across contexts (de Olde et al., 2016; Schader et al., 2014). Sustainability assessment tools are generally meant to enhance sustainable development of farms through the support of on-farm monitoring and decision making, but their success in achieving this goal is not always clear (Coteur et al., 2016). In a comparative analysis between multiple existing tools, Marchand et al. (2014) observed two extremes in tool type: full sustainability assessments (FSA) and rapid sustainability assessments (RSA), with a gradient in between. FSA tools require experts and trained facilitators, and are generally expensive, time-consuming and scientifically underpinned. Meanwhile, RSA tools are more subjective and based on farmer knowledge, but they are cheap, user-friendly and easily implemented across contexts, which generally makes them more effective in triggering farmer participation and interest in learning (Marchand et al., 2014).

To increase validity and success in informing decision making, the selection of indicators and ensuing tool development process should follow transparent and well-defined procedures, in an open collaboration with farmers and end users (de Olde et al., 2017a, de Olde et al., 2017b). In addition, the choice and/or development of an assessment tool usually depends on the data, time and budget limitations of the end users (Gasparatos & Scolobig, 2012). For the purpose of this study, we understand that the Food Systems Center is looking to establish a shared set of metrics that can be used across different farms and locations over time, with minimum data collection, budget and workforce. To respond to these needs, we applied our cross-cultural, mixed-methods PAR approach to the development of an RSA type tool for measuring farm resilience that can be applied across geographic and contextual divides.

To ensure our resilience assessment tool can be easily understood and implemented, we followed a similar score based system for indicator performance as was proposed by Tittonell (2020). Based on the revised resilience frameworks and the collective experience of our research team, we developed three performance levels per indicator, with clear

descriptions of what each level represents (**Table 7**). For each indicator, the mid performance level was used as a desirable threshold, above which we consider farms to be progressing towards resilience (Altieri, 2016). As suggested by Altieri (2016), we recommend to eventually revise these threshold levels in a participatory process, so they can be ultimately determined by the farmers themselves.

The format of this assessment tool allows the facilitators (or the farmers themselves) to understand what each performance level means and to assign the appropriate score (1 to 3, 3 representing the highest performance level) for each of the 20 indicators. After scoring each indicator, the tool calculates the average score per category (i.e., growth mindset, strong relationships, sustainable farming practices, sustainable business management) to highlight overall strengths and weaknesses between indicator sets (de Olde et al., 2017b) and elucidate potential tradeoffs. We then calculated a composite index using the weighted means of each indicator category, which serves as an overall score of farm resilience. An interactive Excel file with the finalized resilience assessment tool is included as Supplemental Material that accompanies this paper. The file includes separate tabs that conduct calculations automatically, and generate a radar chart that can help visualize the results.

Table 7. Twenty indicators of farm resilience, organized into four categories, and descriptions to guide their scoring.

Category	Indicator	Marginal Performance (Score 1)	Acceptable Performance (Score 2)	Optimal Performance (Score 3)
1. Growth Mindset	**1.1. Open attitude**	Farmer recognizes the value of orienting towards a hopeful, optimistic and perseverant attitude in the face of challenges.	Farmer demonstrates efforts towards developing a hopeful, optimistic and perseverant attitude in the face of challenges.	Farmer has an overall hopeful and optimistic attitude, demonstrating self-efficacy and perseverance in the face of challenges.
	1.2. Flexible	Farmer has limited capacity to transform and adapt to unexpected circumstances.	Farmer is cultivating the capacity to transform and adapt to unexpected circumstances.	Farmer is innovative and resourceful, and demonstrates the capacity to transform and proactively adapt to unexpected circumstances.
	1.3. Interest in learning	Limited acquisition and sharing of new knowledge and skills.	Farmer demonstrates a clear motivation to acquire new knowledge and skills. Sharing of such knowledge is limited.	Farmer demonstrates the ability to acquire new knowledge and skills. Knowledge is clearly documented and shared with other farmers and the community. When applicable, local knowledge is honored and revisited.

	1.4. Passion for farming	Farmer gains limited satisfaction and enjoyment from working their land and growing food for the community.	Farmer is gaining a sense of satisfaction and enjoyment for farming through an increased recognition of the value of growing healthy food for the community.	Farmer is dedicated to growing healthy food for their family and community. They feel passionate about working and taking care of their land.
2. Strong Relationships	**2.1. Dependable business networks**	Farmer has made a limited investment in developing reliable partnerships (based on reciprocity and trust) within their business networks.	Farmer is working towards developing reliable partnerships (based on reciprocity and trust) within their business networks, with a steady increase in recurrent orders and payments.	Farmer has cultivated reliable partnerships (based on reciprocity and trust) within their business networks, and can therefore depend on recurrent orders and payments.
	2.2. Community ties	Farmer has limited experience engaging with the local community.	Farmer is engaged with the community primarily through the commercial sale of products in local markets and stores.	Farmer is respected, valued and strongly tied to the community. In addition to the commercial sale of products in local markets and stores, farmer engages with the community through educational talks, agrotourism, and/or training/employment programs for community members.
	2.3. Reliable crew	Farmer has made a limited investment in cultivating crew dependability and independence.	Farmer is actively cultivating crew dependability and independence.	Farm crew is dependable, hardworking, skilled and knowledgeable. Crew independence and motivation contributes to farm viability.
	2.4. Family support	The family does little to support the farm and rarely participates in farm activities. There is limited balance between family time and farm work.	The family is supportive of the farm but rarely participates in farm activities. Farmer aspires to find a balance between family time and farm work.	The family is supportive of the farm and is committed to its success, to the extent that the farm helps strengthen relationships within the family. There is a healthy balance between family time and farm work.

	2.5. Responsive government	There is limited government support or agricultural incentives available.	The government provides support and agricultural incentives when needed, but their guidelines are unclear and their offer is not always equitable.	The government provides reliable support when needed, with minimal uncertainty and bureaucracy. There are clear guidelines and equitable opportunities for agricultural incentives.
3. Sustainable Farming Practices	**3.1. Build healthy soil**	Farmer does not actively implement practices to increase soil fertility or conserve soil.	Farmer is experimenting with practices to increase soil fertility and conserve soil, such as cover-cropping, mulching, composting, recycling biomass, contour planting or rotational grazing.	Farmer regularly implements best practices for increasing soil fertility and conserving soil, such as cover-cropping, mulching, composting, recycling biomass, contour planting or rotational grazing.
	3.2. Protect natural resources and biodiversity	Farmer does not actively implement practices to protect natural resources and biodiversity.	Farmer implements no more than two practices to protect natural resources and biodiversity, such as reforestation, hedgerows, pollinator gardens, wildlife corridors, riparian forests or integrated pest management.	The farm is considered a diverse agroecosystem. Farmer implements three or more practices to protect natural resources and biodiversity, such as reforestation, hedgerows, pollinator gardens, wildlife corridors, riparian forests or integrated pest management.
	3.3. Diversify farm products	One to two crop families surrounded by dominant weeds. There is only one type of animal for livestock.	Three to four crop families surrounded by natural vegetation or dominant weeds. There are only two types of livestock animals.	Five or more crop families surrounded by natural vegetation and/or livestock farming. There are three or more types of livestock animals.
	3.4. Minimize external inputs	Less than 50% of inputs (biomass, agrochemicals, water, etc) originate on the farm.	Between 50-90% of inputs (biomass, agrochemicals, water, etc) originate on the farm.	More than 90% of inputs (biomass, agrochemicals, water, etc) originate on the farm.

	3.5. Water-use efficiency	Farmer does not actively implement practices to increase water-use efficiency.	Farmer is experimenting with practices to increase water-use efficiency, such as irrigation scheduling and/or reduced-volume irrigation systems, according to the specific needs of the agricultural system.	Farmer regularly implements best practices for water-use efficiency, such as irrigation scheduling and/or reduced-volume irrigation systems, according to the specific needs of the agricultural system.
4. Sustainable Business Management	**4.1. Effective planning and monitoring**	Farmer carries out limited planning for each season. No metrics are measured or assessed.	Farmer has a plan for each season, which may be recorded. Goals are not quantifiable, or the data to assess them is not recorded or assessed.	Farmer has a recorded plan for each season. Goals have quantifiable metrics that are recorded and assessed at least annually.
	4.2. Cultivating a healthy workplace	Farmer is working towards offering minimum wage standards, training and support programs, and healthy and safe working conditions. Health and other benefits are not offered. The relationship between the farmer and the work crew could be improved. Workplace discrimination and harassment is not currently addressed.	Farmer offers fair wages. Other benefits, training and support are limited. The relationship between the farmer and the work crew is strictly professional. Workplace discrimination and harassment is not tolerated, but there is no system in place to prevent and/or address it appropriately.	Farmer offers fair wages, health insurance and other benefits. They offer training and support when needed, and there is good rapport between the farmer and the work crew. Workplace discrimination and harassment is not tolerated, and there is a system in place to prevent and/or address it.
	4.3. Diversifying markets and venues	Farmer sells primarily through one type of market channel such as direct-to-consumer, CSA, farmstand, farmer's market, wholesale to grocery, wholesale to restaurants, or wholesale distributor.	Farmer sells through two different market channels such as direct-to-consumer, CSA, farmstand, farmer's market, wholesale to grocery, wholesale to restaurants, or wholesale distributor.	Farmer sells through three or more different market channels such as direct-to-consumer, CSA, farmstand, farmer's market, wholesale to grocery, wholesale to restaurants, or wholesale distributor.

	4.4. Financial leeway and capacity	Farmer is working towards achieving positive net income. Farmer supplements farm finances with off-farm income, loans or uncompensated labor.	After covering all expenses and production costs, farmer has less than 30% income surplus, some of which could be reinvested into farm infrastructure, land, or other long term assets. Net farm income is rising or neutral year to year.	After covering all expenses and production costs, farmer has more than 30% income surplus, some of which could be reinvested into farm infrastructure, land, or other long term assets. Net farm income is rising year to year.
	4.5. Appropriate equipment and infrastructure	Most equipment and infrastructure needs on the farm are unmet. The farm currently requires additional capacity in order to grow, process, and store sufficient product to support the farm.	Most equipment and infrastructure needs are adequately met. The farm would need to expand or acquire additional equipment and infrastructure to increase the amount of food they could grow, process, and store.	Equipment and infrastructure functions reliably and is designed for the tasks required. The farm has enough to grow, process, and store more than the current amount of food that they produce.
	4.6. Focusing on recurring customers	Less than 25% of sales stem from customers who purchase regularly - be it weekly, monthly, or annually based on what constitutes regular for the farm's specific market.	25%-75% of sales stem from customers who purchase regularly - be it weekly, monthly, or annually based on what constitutes regular for the farm's specific market.	Over 75% of sales stem from customers who purchase regularly - be it weekly, monthly, or annually based on what constitutes regular for the farm's specific market.

Potential Challenges and Limitations

First, it is important to note that our tool is meant to assess farm resilience specifically, as we consider resilience to be essential for a system to become more sustainable overall (Marchese et al., 2018). By integrating “Positive Deviant” farmers in our PAR approach, we managed to identify specific practices and behaviors that farmers can adopt to increase their resilience. However, even though our tool is primarily farmer-centric, there are some indicators (e.g., responsive government, dependable business networks) that may be external and systemic in nature, which makes them difficult to compare and/or control. This raises the issue of agency in complex systems, and highlights that resilience often emerges in response to outside challenges.

The application of most rapid assessment tools requires users to make subjective decisions. As such, the scoring of each indicator in our assessment tool will highly depend on the judgement and training of the facilitator, as well as the openness and precision of the farmer responses. Thus, there is the inevitable possibility of outputs that have lower accuracy and reliability (Marchand et al., 2014). In addition, by including only three scoring levels per

indicator, we could be oversimplifying farmer responses and limiting our potential to capture the broader spectrum of variability that farms can exhibit. Prior to applying the tool, practitioners should reflect on whether the amount of detail provided is appropriate for the goals of the monitoring program and if it will help answer their questions of interest. If necessary, the threshold levels could be modified or the criteria could be adapted to include finer degrees of change among scores, which might make the results more contextually sensitive and locally appropriate (Altieri, 2016; Bell & Bellon, 2018). We describe a process for doing that in the section on Tool Implementation below.

Finally, there are many other resilience indicators in the literature that were not necessarily captured in our assessment tool, such as ecological self-regulation and food self-sufficiency (Altieri, 2016; Cabell & Oelofse, 2012; Tittonell, 2020), to name a few. Nevertheless, we stand by our final selection of indicators, since they surfaced through collaborative and transparent interactions with farmers, in addition to review of the literature. In addition, when given the chance, the farmers did not suggest additional resilience factors that could be added to the list. Ultimately, since the choice of indicators is dependent on the input of specific farmer participants, this tool might be improved by repeating this exercise with a greater number of farmers across a wider range of geographies and cultures.

Discussion

Tool Implementation

The farm resilience assessment tool, combined with our above-described cross-cultural PAR approach, can provide an agroecological lens through which a farm's pre-existing social capital, resources and goals can be focused over time. We propose that this focus will amplify and synchronize an increase in the health and resilience of participating farms and thus the local food systems in which they operate.

Below is a six-step proposal for how to implement the tool, and refine it as necessary. The proposal is place-based and local, yet also replicable across the globe, wherever there are farms with the existing intention, support, and resources needed to make positive change. Note that implementation of this process will require a budgetary plan that is not discussed here.

<u>Step 1: Recruit/Select Farmers and Launch Project</u>

- Selection of farmers should occur through a collaborative process that both A) draws on existing relationships and synergies between study facilitators (researchers and service providers) and farmers, and B) also allows for farmers to "self-select" in response to a call for participation within a local farm community. We will refer to these farmers as Positive Deviants (PD) owing to their interest in resilience and in participating in the project.
    - The number of participants can vary but we recommend a group with less than 15 individuals so that personal interactions can more freely occur.
    - We recommend trying to include diversity in terms of crops, products, growing techniques, habitats, etc.

    - We also recommend including cross-cultural diversity from distinct geographic settings, to extend the range of perspectives that will contribute to the project.
- Financial incentives should be provided, as they help to formalize and value the farmers' role in the project.
- Once selected, all participating farmers attend a virtual kick-off meeting, where they introduce their farms (with photos), and where research facilitators outline the project goals and application of the indicator tool. It is important to establish trust during this first stage of the process.

Step 2: Establish Resilience Baseline and Improvement Goals for each Participating Farm

- Food Systems Center staff or partner organizations meet one-on-one (virtually or in-person) with each participating farmer.
- More fully explain, as needed, the resilience assessment tool and its purpose.
- Apply the tool and rapidly score each farm's baseline resilience based on the 20 proposed indicators.
- Discuss the results and the radar chart with the farmer, to incentivize reflection with regards to their resilience.
- Identify 1 to 3 actionable, on-farm improvement projects farmers want to complete over the next two years, potentially for multiple reasons.
- Choose which (3 to 5) of the 20 indicators will best "reflect" the positive changes they predict will be caused by completion of their identified improvement projects.

Step 3: PAR Feedback and Indicator Revision/Validation

- Farmers meet all together, virtually with research facilitators, to discuss their proposed projects, and refine/validate the selected indicators and listed scoring levels included in the assessment tool.
- Farmers complete, if needed, a follow-up survey to reinforce or clarify PAR feedback, refine threshold levels, or add additional levels of scoring.
- Facilitators refine target indicator levels, as needed, in response to PAR feedback.

Step 4: Launch Improvement Projects

- Facilitators meet with farmers individually to define an improvement project support team, as needed, to accomplish project goals.
    - Improvement project support team will likely include existing service and technical support advisors in their area (e.g. UVM Extension, Farm Viability). It is important to also consider other service providers that the farmer has in mind.
- Facilitators host an initial support team meeting for each farm, to introduce the team, and help kick off the farm's improvement project(s).

Step 5: Complete PAR-based Improvement Projects and Track Changes in Resilience

- Over two years, the cross-cultural PAR team meets quarterly (virtually) to report on/ discuss progress and barriers in each project.
    - These meetings could be in sub-groups based on project types and chosen indicators.
    - Findings should be communicated with the Food Systems Center

- For each farm, repeat the resilience assessment at the end of years 1 and 2.

Step 6: Amplification and Dissemination of Results through Cross-Cultural Exchange

- Organize reciprocal, cross-cultural "farmer in residence exchanges" (FIRE), where-in subsets of farmers engage in practical knowledge transfer by visiting and working on other farms located in distinct cultural and geographic settings.
    - These could occur concurrently with the implementation of projects outlined in Step 5.
- Farmers present results of project implementation and lessons learned at annual meetings (with in-person and virtual activities) attended by farmers, practitioners, and researchers from the participating regions.
    - For example, in Vermont the VVBGA annual meeting, attended by hundreds of Vermont's lead farmers, is a prime opportunity for the dissemination/amplification of these lessons learned. In Puerto Rico, the Cooperativa Orgánica Madre Tierra and the Model Forest initiative are two groups with members who would be interested in learning about the PAR projects and could provide insight about further adapting the resilience tool to the context of place and culture.

Scaling-Up to Global Sustainability

Broad application of agroecological principles and resilience indicators at local scales can also contribute to global advances in achieving planetary sustainability. Current crises such as the COVID-19 pandemic and climate change have sparked calls for a restructuring of agroindustrial systems around agroecological practices that strengthen connections between small-scale food production and local consumption, thereby reducing risks to human health and the environment, and minimizing disruptions of food supplies (Altieri & Nicholls, 2020). As noted earlier, there are clear linkages between agroecology and the Sustainable Development Goals. This includes goals that explicitly include ecological elements of food systems, in addition to other socially-oriented objectives (FAO, 2018a; Pimbert, 2018).

The four categories presented in our resilience indicator tool -- Growth Mindset, Sustainable Farming Practices, Strong Relationships, and Sustainable Business Management -- align well with a multitude of SDGs. These include, but are not limited to, goals that emphasize ending hunger through sustainable agriculture (Goal 2), promoting health and well-being (Goal 3), ensuring access to clean water resources (Goal 6), promoting decent work and sustainable business practices (Goal 8), reducing economic, cultural and gender-based inequalities (Goal 10), making cities resilient and sustainable (Goal 11), ensuring sustainable production and consumption patterns (Goal 12), combating climate change (Goal 13), conserving and sustainably using marine and terrestrial resources (Goals 14 & 15), and strengthening partnerships implementation (Goal 17). It is our hope that in using the resilience indicator tool presented here, facilitators and farmers will be able to internalize the holistic nature of the SDGs, recognize their relevance to their farm systems, and find tangible ways to put the aspirations behind the goals into practice.

Beyond direct implementation by individuals and small groups, future work should consider what steps need to be taken to transition from potentially fragmented actions to coherent landscape scale planning and policies that integrate agroecology principles with sustainable resource management and production strategies. There is great potential for coordinated efforts at regional scales through cross-site coalitions that promote sustainability education and policy advancement, such as the Global RCE Network. RCEs represent multi-stakeholder networks and education alliances that seek to enhance leadership and capacity development, and advance knowledge through policy-relevant research that contributes to the realization of the SDGs. In forthcoming research endeavors, we aim to draw on the diverse array of places and partners who collaborate within the RCE Network, both in the Americas and beyond, and explore how the ideas presented in this paper can be brought to scale through the exchange of knowledge, expertise, resources, and best practices.

Lessons Learned from Farmer Participation

Including farmers from Puerto Rico and Vermont in this project augmented the range of perspectives that helped inform sustainable food system metrics and resilience indicators. Six of the most salient takeaways were the following:

- There is an incredible diversity of farming practices and models. However, there are more similarities than differences between farmers, even across geographic and cultural divides, and resilience is important for all.
- The answer to resilience is not a product. Mindset qualities such as flexibility and passion, and strong relationships with family and the community, are integral to achieving resilience.
- Hearing from other farmers' experience and efforts towards resilience was extremely educational and inspiring for many participants. This highlights the importance of farmer-to-farmer knowledge sharing and the creation of farmer networks.
- We could not have arrived at the range and depth of understanding about the resilience indicators without engaging farmers in the PAR process.
- Actively seeking out and integrating positive deviants rather than selecting a random sample of farmers streamlined the path to identifying indicators and examples of resilience.
- Having a diverse group of farmers interacting across two distinct geographies and cultures created a powerful dynamic that was important for everyone to think more broadly about the nature of resilience.

Furthermore, we observed vigorous interest in further enhancing collaboration between researchers and farmers via farmer-to-farmer and researcher-to-farmer visits. The farmers recommended hands-on experimental trials and in-person interactions in the field. This suggests that, even though the study was conducted in a fully virtual format due to the COVID-19 pandemic, in-person meetings and visits to research sites are important for building trust and understanding, and nurturing mutually beneficial relationships. Several farmers also expressed interest in participating in subsequent research phases that might occur in the future.

Lastly, we observed some patterns of similarities and differences between the farms in Puerto Rico and Vermont. For example, “build healthy soil” displayed a transcultural relevance for sustainable farming practices, while “water-use efficiency” presented discrepancies in the order of importance between the considered regions, with Puerto Rico reporting it as a higher priority. Conducting an analytical comparison between the two places was beyond the scope of this study, yet the observed variability highlights a valuable lesson: correctly interpreting correlations and divergences between different places will require careful consideration of the indicator tool outcomes through the appropriate contextual lens.

Concluding Remarks

As exemplified in recent publications by Béné (2020) and Altieri and Nicholls (2020), the COVID-19 pandemic has brought into sharp focus the critical importance of small farm resilience to the well-being of communities around the world. Their findings validate our own work by underscoring the value of both focusing on the quality of relationships farmers have with other members of the food systems, and moving from documenting capacity to cultivating actual resilience.

Although a central outcome of our work over the past six months has been the development of the toolbox of measurable resilience indicators, we want to emphasize that it has been the *process of engaging* with the farming community that is truly at the heart of effecting positive change in food systems. Local food systems research can be thought of as an interwoven social network that grows and strengthens over time – before, during, and after the research period. Existing relationships and collaborations between a region’s researchers, service providers, and farmers are often based on social capital, and form the key social network through which the research progresses. Choosing positive, successful, and resilient farmers (positive deviants) has a significant catalytic impact on this type of work, and can leverage long-term, meaningful change within a community. Employing PAR across cultures and geographies enlivens and enlightens the interaction process, helping participants think outside the box of their farm and community.

Sustainability is ultimately about the quality of relationships within systems, and this certainly holds true when it comes to the relationship between food systems researchers, and farmers. A hallmark of this relationship should be authentic reciprocity; researchers must commit to building real and synergistic relationships with participants acting as co-producers of knowledge, and then use the positive feedback from this synergy to effect real change. Thus, food systems research must integrate objective and subjective methods in order to cultivate the relational synergy needed to address and transcend the complex problems we face in the 21st Century.

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Appendices

Appendix I. Principles of agroecology (CIDSE, 2018) and several related Sustainable Development Goals.

Appendix II. Farmer Report from the Field

Introduction
Hi, folks! Thanks for your willingness to participate in this project about resilience and sustainability on small farms. We greatly value your knowledge and "on the ground" experience as farmers. Our research is guided by two conceptual frameworks: 1) the Principles of Agroecology, which emphasize the integration of economic, political, environmental, and socio-cultural dimensions for cultivating and maintaining healthy food systems; and 2) the United Nations Sustainable Development Goals, which aspire to achieve local and global objectives related to Life on Land, Zero Hunger, Good Health and Well-Being, Reduced Inequalities, and Climate Action, among others. Your input will help us translate those ideas into real-world metrics and indicators that can help promote farm sustainability in the midst of major economic, socio-political, and environmental challenges.

* Required

Email address *

How are things going?

For this first activity, we want to hear from you about how things are going for you and your farm during this growing season (from March 2020 to the present). Below is a list of eight categories (or "context areas") based on the Agroecology frameworks described above. Please "take the pulse" of your farm within each category, ranking your attitudes and perceptions for this season, on a scale of 1 to 5. All of these categories may have both positive and negative attributes, and your rank should reflect the balance of these.

Please choose one rank that best describes your feeling overall, over the last 6 months, where,

1 - bad- couldn't be worse
2 - could be better
3 - doing OK... overall neutral
4 - doing well
5 - great- can't get any better

If you wish to include further comments or concerns you are welcome to do so using the spaces provided for open responses following each category. You do not need to provide any personal information regarding your production or income.

1. Farm Vulnerability -- This refers to the big-picture functionality/capacity of your farm, given external, systemic shocks and stressors such as government services, extreme weather events, coronavirus pandemic, home schooling of children, etc. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... on balance neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Farm Vulnerability (optional)

2. Natural Resources -- This refers to ownership or access to land for cultivation or pasture, availability of seed, livestock, fertilizers, pest control, etc. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... on balance neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Natural Resources (optional)

3. Human Capital -- This includes availability of farm workers (for example, a family operation or a crew of hired employees), the interpersonal dynamics, and production efficiency. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... on balance neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Human Resources (optional)

4. Farm Work -- This refers to your work on the land, or the fruits of your labor (seeding, watering, fertilizing, feeding, cultivation, controlling pests, harvesting, slaughtering, post-harvest crop processing, and livestock production output, etc.). *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Farm Work (optional)

_____

5. Processes & Institutions -- This includes local and national policies that affect farm viability, such as regulations, insurance, financial assistance, technical assistance, etc. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Processes & Institutions (optional)

_____

6. Markets -- This refers to the availability of markets, and interactions/relationships with your customers/business/community. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Markets (optional)

_____

7. Financial -- This includes costs for material supplies and services, income sufficiency, food security, and farm profitability. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Financial (optional)

8. Personal -- This refers to life balance of work vs. rest; time for farm needs as well as for self, family, friends, and community. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments for rank of Personal (optional)

All together now...., please rate your overall attitude for all eight categories combined. *

Mark only one oval.

- ◯ 1 - bad- couldn't be worse
- ◯ 2 - could be better
- ◯ 3 - doing OK... overall neutral
- ◯ 4 - doing well
- ◯ 5 - great- can't get any better

Additional comments or concerns for overall ranking (optional)

Describe some "stand out" moments or events

Finally, please respond to the following prompts, either by providing written comments or uploading a short audio recording or video. Again the timeframe of interest is during the current growing season (last 6 months).

1. Describe a few (1 to 3) positive or meaningful moments, events or interactions associated with your farm.

2. Describe a few (1 to 3) negative, difficult, or frustrating moments, events or interactions associated with your farm.

3. Provide any additional comments you wish to add, especially questions or categories that you think are missing in this report.

All done--thanks for your report from the field!

We'll be in touch soon about the next steps in the project.

Appendix III. Interview Guidelines

Introduction / Lead-in

Explain that:

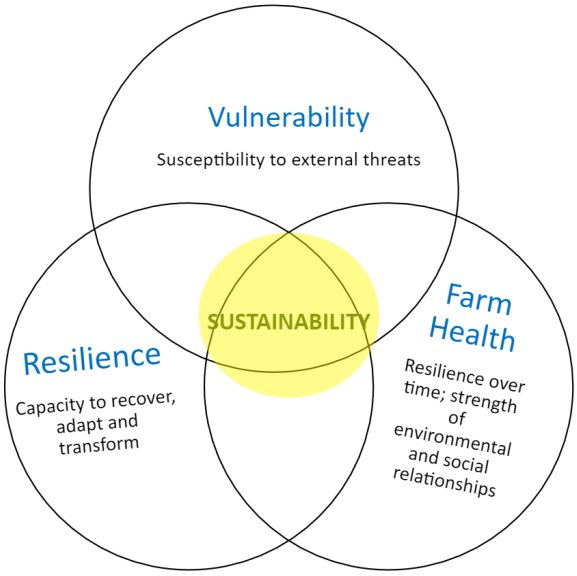
- We are following up to dig a bit deeper into some of the things they touched on in their reports from the field.
- This is participatory research--we will use their responses to help develop a versatile strategy and methods for evaluating "sustainable" or "healthy" farm systems. Herein, we are hoping they can frame their understanding of the most important or meaningful ways to describe and measure the "health" of their own farm / farm community.
- The compilation of their subjective views will be the foundation of the research methods we will propose in our forthcoming "white paper".
- We will organize around a few guiding questions or "topics". We anticipate this will take about an hour to an hour and a half…., and we will stay focusses on these questions.

Semi-structured Interview Guide

Units of Analysis Each number (1, 2, 3…) are different segments of analysis. Under each segment we have specific questions, based on our project's aim and objectives. These segments of analysis help to facilitate the coding process (e.g., identify key issues, commonalities, differences, compare, etc., under specific topic areas), based on Saldaña (2018).[1]

1. **Definitions:** Our first task is to make sure we are on the same page with the guiding terms for this interview: Vulnerability, Resilience, and Farm Health, and your own subjective experience within your farm system.

[1] Saldaña J. (2016). *The Coding Manual for Qualitative Researchers*. London: SAGE.



Potential sub- questions for Interviewer to ask:

- Do you have any questions about these general definitions? agree with the definitions? different perspective to share about the definitions? Questions? Comments?

2. **Resilience:** Describe specifically, how you and / or your farm have responded to challenges or adapted during difficult times. We want to learn about your strengths ("to illuminate their elements of success and well-being", their "social, synergistics and/or cathartic happenings") , based on their own experiences, and explore metrics around these elements of success.

Potential sub- questions for Interviewer to ask:

- What have been the greatest challenges you have experienced on the farm during the current growing season?
- Describe any skills, strengths, wisdom, or knowledge you drew on to address or adapt to these challenges
- If possible or relavent, add comments / questions about resilience in the pandemic, specifically

3. **Relationships:** With respect to the health of your farm, Describe the quality of your relationships with other key stakeholders (i.e. market/consumers, community,

government). and explore if, how, and why you have worked improved/strengthened these relationships.

Potential sub- questions for Interviewer to ask:

- Who are the key partners/stakeholders/entities, such as buyers and government agencies (important relationships) that influence the success of your farm? Think about sketching a relationship web diagram for your farm.
- Describe how these other key relationships influenced or helped shape the development of your farm?... or influenced how you have responded during challenging times such as the pandemic, or following catastrophic weather events?
- Describe the nature of your relationships with one or more of these stakeholders (such as how and when and why you relate...and about what kinds of things)...
- In addition, Reflect more deeply on the positive or meaningful or important parts of the relationship(s)? ...What are the negative or stressful parts, and how could they be improved?

4. **Vulnerabilities of the farm system:** To learn where they still need help - their challenges based on their own experiences, and explore metrics to help measure these vulnerabilities.

Potential sub- questions for Interviewer to ask:

- Based on our research team definitions sent before this interview, Describe what you see as the main vulnerabilities your farm has faced in the last year? (example: challenges...economic, labor, material inputs, market access, pandemic, natural disasters.)
- Describe the most difficult or vexing part(s) of these challenges?
- What do you think you need (from the outside), or need to do (form the inside), to reduce those challenges and vulnerabilities within the few years? (what kind of resources, what changes?)

5. **Farm Health:** How they describe and envision the health of their farm system now and looking ahead (like five or ten years from now). Related to a healthy farm/business (i.e. their social-agricultural system) , and explore metrics based on their vision.

Potential sub- questions for Interviewer to ask:

- Using our definition of farm health (resilience over time), reflect on what that health feels like on your farm/ within your farm system
- Looking ahead, describe a vision of "health" for your farm system, say in the next five to ten years?
- Why is this vision important or meaningful to you, and / or how do you hope it could help you , your farm, your family, your community, your planet :)
- What do you need, or need to do to achieve this vision?

6. **Reflect on the cross-cultural aspect of our participatory research.** e.g., what they want to learn from each other, if they would like to keep exploring and expanding this cross-cultural experience next year and, if yes, how?

Potential sub- questions for Interviewer to ask:

We see the cross-cultural perspectives and sharing are an important part of this project and future collaborations:

- What, if anything, are you hoping to learn from other farmers participating in this project, including those from Puerto Rico and Vermont?
- Do you have any suggestions for how to structure our final PR-VT panel discussion (e.g., How on Zoom could we envision or plan future cross-cultural farm exchanges or research?)

7. **Additional concerns, ideas they want to share with the Team**

Potential sub- questions for Interviewer to ask:

- Is there anything else you would like to express, regarding the previous questions, or other topics of interest?

Appendix IV. Closing Survey

To our valued farmer collaborators:

A hearty thanks for your participation in the project. Your perspective and experience have greatly enriched the research process and contributed to our understanding of food systems sustainability on farms in Puerto Rico and Vermont. With this final activity, we'd like to follow up on what we presented in the group Zoom meeting and get more feedback about the main themes and indicators that were mentioned in the individual interviews. If you'd like to watch the video recording of the meeting you can access it here: https://streaming.uvm.edu/private/videos/efvo7zg/.

We'd also like to receive feedback about your experience participating in the project, and have a few questions about what you learned, ideas for improvement, and suggestions you might have for future collaborations.

We would greatly appreciate it if you would complete this survey by Sunday, December 27. Your input will help us as we prepare the final report of the project findings. Best wishes for a safe and happy holiday season!

* Required

What is your email? *

How would you rate the following MINDSET QUALITIES in terms of their importance for increasing the resilience and health of your farm? (see some examples in parentheses) *

Mark only one oval per row.

	Not important	Slightly important	Important	Very important
OPEN ATTITUDE (perseverant, hopeful, optimistic, embraces challenge)	◯	◯	◯	◯
FLEXIBLE (adaptable, multifaceted, able to transform depending on the circumstances)	◯	◯	◯	◯
INTEREST IN LEARNING (curious, motivated self-learner, embraces new knowledge and skills, learning from experience)	◯	◯	◯	◯
PASSION FOR FARMING (strong commitment to growing healthy food for family/community and working the land)	◯	◯	◯	◯

How would you rate the following RELATIONSHIPS in terms of their importance for increasing the resilience and health of your farm? (see some examples in parentheses) *

Mark only one oval per row.

	Not important	Slightly important	Important	Very important
DEPENDABLE BUSINESS NETWORKS (reliable and loyal customers, direct and transparent partnerships, recurrent orders and payments)				
COMMUNITY TIES (farm and role as farmer is strongly supported and valued by the community, feeling of solidarity and embeddedness)				
RELIABLE CREW (crew is skilled and knowledgeable, hardworking, creative problem solvers, good rapport)				
FAMILY SUPPORT (family supports and may work on the farm, healthy family/work balance)				
RESPONSIVE GOVERNMENT (reliable support in times of crisis, reduced uncertainty and bureaucracy, clear guidelines and just opportunities for economic incentives)				

How would you rate the following SUSTAINABLE FARMING PRACTICES in terms of their importance for increasing the resilience and health of your farm? (see some examples in parentheses) *

Mark only one oval per row.

	Not Important	Slightly Important	Important	Very Important
PROTECT NATURAL RESOURCES AND BIODIVERSITY (reforestation, hedgerows, pollinator gardens, wildlife corridors/habitat, contour farming)	◯	◯	◯	◯
BUILD HEALTHY SOIL (recycling biomass, cover-cropping, mulching, composting, building soil fertility)	◯	◯	◯	◯
DIVERSIFY FARM PRODUCTS (multiple crop types (fruits, roots, greens, shrubs, trees, etc), crop rotations, livestock--crop integration)	◯	◯	◯	◯
MINIMIZE EXTERNAL INPUTS (reduced or no use of agrochemicals, on-farm nutrient retention, seed production)	◯	◯	◯	◯
WATER-USE EFFICIENCY (drip or trickle irrigation system, rainwater harvesting)	◯	◯	◯	◯

How would you rate the following BUSINESS MANAGEMENT PRACTICES in terms of their importance for increasing the resilience and health of your farm? (see some examples in parentheses) *

Mark only one oval per row.

	Not important	Slightly important	Important	Very important
EFFECTIVE PLANNING AND MONITORING (business and marketing plan, tracking sales and market trends, financial review and reset)	◯	◯	◯	◯
CULTIVATING A HEALTHY WORKPLACE (fair wages, respect and trust, training and support, open to feedback, positive rapport and morale)	◯	◯	◯	◯
DIVERSIFYING MARKETS AND VENUES (CSA, farm store/stand, farmers' markets, wholesale, online orders, delivery or pick-up)	◯	◯	◯	◯
FOCUSING ON RECURRENT CUSTOMERS (prioritizing loyal customers, withdrawing from unreliable markets)	◯	◯	◯	◯
APPROPRIATE EQUIPMENT AND INFRASTRUCTURE (access to essential and functional equipment - trucks, tractors, tools, wash tanks, cold storage)	◯	◯	◯	◯
FINANCIAL LEEWAY AND CAPACITY (positive cash flow, access to appropriate capital and credit, off-farm income)	◯	◯	◯	◯

Is there anything we may have missed in the previous lists that you think is worth including?

From the list below, mark the three (3) factors that you consider most important for the resilience and health of your farm.

Mark only one oval per row.

	Most important (please only select 3)
Open attitude	◯
Flexible	◯
Interest in learning	◯
Passion for farming	◯
Dependable business networks	◯
Community ties	◯
Reliable crew	◯
Family support	◯
Responsive government	◯
Protect natural resources and biodiversity	◯
Build healthy soil	◯
Diversify farm products	◯
Minimize external inputs	◯
Water-use efficiency	◯
Effective planning and monitoring	◯
Cultivating a healthy workplace	◯
Diversifying markets and venues	◯
Focusing on recurrent customers	◯
Appropriate equipment and infrastructure	◯
Financial leeway and capacity	◯

What have you learned through your participation in this project? *

Through this project, have you been inspired to try anything new on your own farm in the future? If yes, please comment on this further. *

Do you have any recommendations for enhancing the level of collaboration between researchers and farmers? *