Using Spatial Technology to Support Community Resilience for Landscape and Food Systems in the U.S. Virgin Islands

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Abstract: This case study will showcase the use of spatial data and technology to promote community, landscape, and food systems resilience in the U.S. Virgin Islands. We explore the inventory and analysis stage of landscape architecture using place-based and public-interest design processes and then investigate the strengths and challenges of primary data collection for landscape design and food systems development in a community with gaps in internet connectivity and limited existing digital data. We demonstrate the usefulness and intent for integrating primary data collection, mapping and community decision making for place-based planning. This process, and use of a mobile application tool (Fulcrum), is believed to be a transferable process for similar communities with minimal data resources and internet connectivity.

Keywords: Data digitization, resilience, food systems, mapping technology, mobile data collection

1 Introduction

In early 2017, our cross-disciplinary team at Iowa State University (ISU) was teaching a national certification program for community food systems when we met with an organization from the U.S. Virgin Islands, which needed support to develop local food systems in the Territory. Later in the year, as our teams started to work together, two Category 5 hurricanes hit the Territory. Farmers, food businesses and community members took action to help understand and alleviate some of the burden the natural disaster put on the local food system. The impact of the hurricanes accelerated our partnership, spurring our team to provide assistance with hurricane response and development of the local food system.

Our team first responded by conducting on-site interviews and listening sessions designed to record the impacts of the natural disaster on businesses, organizations, farmers and community members. This initial response led to many discussions about creating a more resilient food system in the future, including the ability to prepare, respond, recover and rebuild. Our definition of a resilient food systems is the capacity for place and values-based food systems, and the actors within, to be able to withstand shocks and disruptive pressures while maintaining basic structures, processes and functions of the community food system and supply chain; ensure the ability to produce and access nutritious and culturally acceptable food over time and space; and create a responsive and functional paradigm (FAINSTEIN 2014, CAMPANELLA 2006, SCHIPANSKI et al. 2020). Shocks can range widely from economic crises, natural disasters, environmental impacts of climate change and social and political forces, all of which can evolve over time. These shocks impact the liveability of a community or landscape region.

To prepare, plan and respond, it is important to have a baseline understanding of existing local conditions and resources. Based on the response protocols identified, we recognized

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major gaps both in data availability and in organizational capacity to respond effectively to shocks. Digital landscape and place-focused tools are a necessary component to collect information when extant data is not readily available. New data metrics are needed for future use and development of a resilient landscape and local food system for the Territory. Robust spatial data would allow for further understanding of existing conditions and locations of farms and food businesses. Therefore, the team worked to map out conditions of each island and determine design strategies for response. We prioritized digital solutions and mapping technology as an initial method to fill the gap that was identified. Over the following years, we formed strong relationships with many organizations across the Territory and supported our partners through research, facilitation and conceptual design tactics related to priorities determined from spatial data analysis. This included work with FEMA on a food system assessment, which was the first opportunity to highlight mapping and landscape design strategies (LONG et al. 2019). Following the assessment in 2019, we prioritized projects for farmers and food businesses, including development of virtual farmers market framework and resilient food system action plan.

In this paper we detail a process for working with community members to identify and create new data through digital geospatial technologies and utilize findings to support data driven decision making. We demonstrate how technology innovation, within a community that lacks data resources and has limited internet connectivity, can be developed though a mobile data collection tool. We show how digital skills, tools and processes within Landscape Architecture, such as GIS analysis, site field research, occupancy identification and conceptual design allowed for identification and understanding of existing landscape and environmental conditions to inform decisions for resilient food system opportunities within the community. By inventorying and visualizing existing open-source spatial data, performing analysis of data to identify gaps, using open-source GIS software (QGIS) and creating a customized spatial data collection app, community partners will be able to support the development, maintenance and administration of a virtual farmers market in the future.

2 Background

2.1 Study Area Overview

The U.S. Virgin Islands is a territory of the United States and consists of a group of four Caribbean islands: St. Thomas, Water Island, St. John and St. Croix. The islands to the north, St. Thomas, Water Island and St. John, consist of hilly and at times very steep terrain due to their volcanic origins. St. Croix, the largest island in land area, lies to the south and has much flatter terrain. Because the islands have significant differences in physical geography, they differ in the type and availability of farmland and farming opportunities available to residents of each island. St. Croix is larger by size, least densely populated and economically industrial. St. Thomas is smaller in size but has a denser population driven by a strong tourism industry. Virgin Islands National Park takes up 60 % of St. John's land area, making the island a tourist attraction and limiting population capacity and farming. Tab. 1 displays population changes that likely occurred due to natural disasters and economic factors.

Table 1: Total population for the U.S. Virgin Islands and it's populated islands from 2010 and 2020. Population change calculated between 2010 and 2020 (U.S. CENSUS BUREAU 2020)

	2010	2020	Change (%)
St. Croix	50,601	41,004	-19 %
St. John	4,170	3,881	-6.9 %
St. Thomas	51,634	42,261	-18.2 %
Water Island	182	164	-9.9 %
U.S. Virgin Islands	**106,405**	**87,146**	**-18.1 %**

Around 12 % of the Virgin Islands territory is comprised of agricultural land (THE WORLD BANK 2018). As of 2017, the U.S. Virgin Islands had 565 farms, increasing from 219 in 2007 (USDA NASS 2018). The USDA defines a farm as an operation where $500 or more of agricultural products are sold within a year. The 565 farms account for 9,324 acres of land, with 2,620 acres of cropland and 5,538 acres of pasture or grazing land. The average farm size in the Territory is 16.5 acres. Of the islands, St. Croix has the largest average farm size of 17.9 acres, while St. Thomas and St. John has an average farm size of 10.2 acres. A majority of farms in the Territory (59 %) operate their farm business from their residence (USDA NASS 2018). Farms not operating from private residences are typically on government-owned land. The government has defined policies and regulations related to land use and build infrastructure (see Fig. 1 for two examples of farms in the Territory). One of the most significant policies that impacts renters is that only temporary structures are allowed. Tenant farmers commonly use freight or shipping containers as temporary structures for their equipment storage needs. However, unless they are heavily weighted or anchored down, they are unable to withstand high winds and can flip over and cause additional damage to equipment and land.

Fig. 1: Photos from farms in the U.S Virgin Islands, taken by Courtney Long

2.2 Project Background

We first sought to understand impacts of the hurricanes through qualitative analysis with interviews and focus groups. The ability to understand, identify and assess current conditions was quickly seen as a constraint within our work. The Territory lacked accurate record keeping and updated census information. Additionally, when interviewing farmers about the impact from the 2017 hurricanes, many spoke about gaps in record keeping as well as losing paper copy receipts and other records during the storms. Because of this, many farmers and businesses did not receive adequate compensation for rebuilding their farm, and, without updated Census information it was difficult to track the movement of people post-storm.

Following this work, we broadened our team to include data expertise, geospatial design and landscape architecture to enhance the efforts around inventory and analysis. As our team worked to collect data, we identified significant gaps in the availability of geospatial data. We also recognized differences in the addressing system that led to difficulties with general navigation, and place-finding and geocoding. The addressing system originally designed in the Territory used estate names and plot numbers rather than street names and sequential numbering. Plot numbers were not assigned in an orderly manner, as street numbers are in U.S. states. This resulted in a confusing pattern of numbering, making finding individual houses or business locations difficult. Because of these complicating factors, it is common to have multiple parcels with the same address in the same Estate. For example, the address 2 DA Nazareth and 2 DA Secret Harbor/Nazareth are both located in Estate Nazareth but are different addresses (Fig 5). The development and transition to a modern addressing system has been underway for about a decade, but a staggered rollout has led to confusion and inconsistencies in address reporting.

These addressing challenges made it difficult to understand where farm and food businesses were located pre- and post-storm. Therefore, we needed to collect location data using coordinates rather than relying on addresses. To achieve this, we needed to identify a mobile application that could collect GPS coordinates site amenities, product inventory and sales information. A USDA Farmers Market Promotion grant funded this search. In the following sections we detail the process of utilizing digital landscape tools to digitize data, create an accurate directory of businesses, and identify a partner organization to support the farmers market services. Figure 2 lists the activities completed to date in partnership with U.S. Virgin Islands.

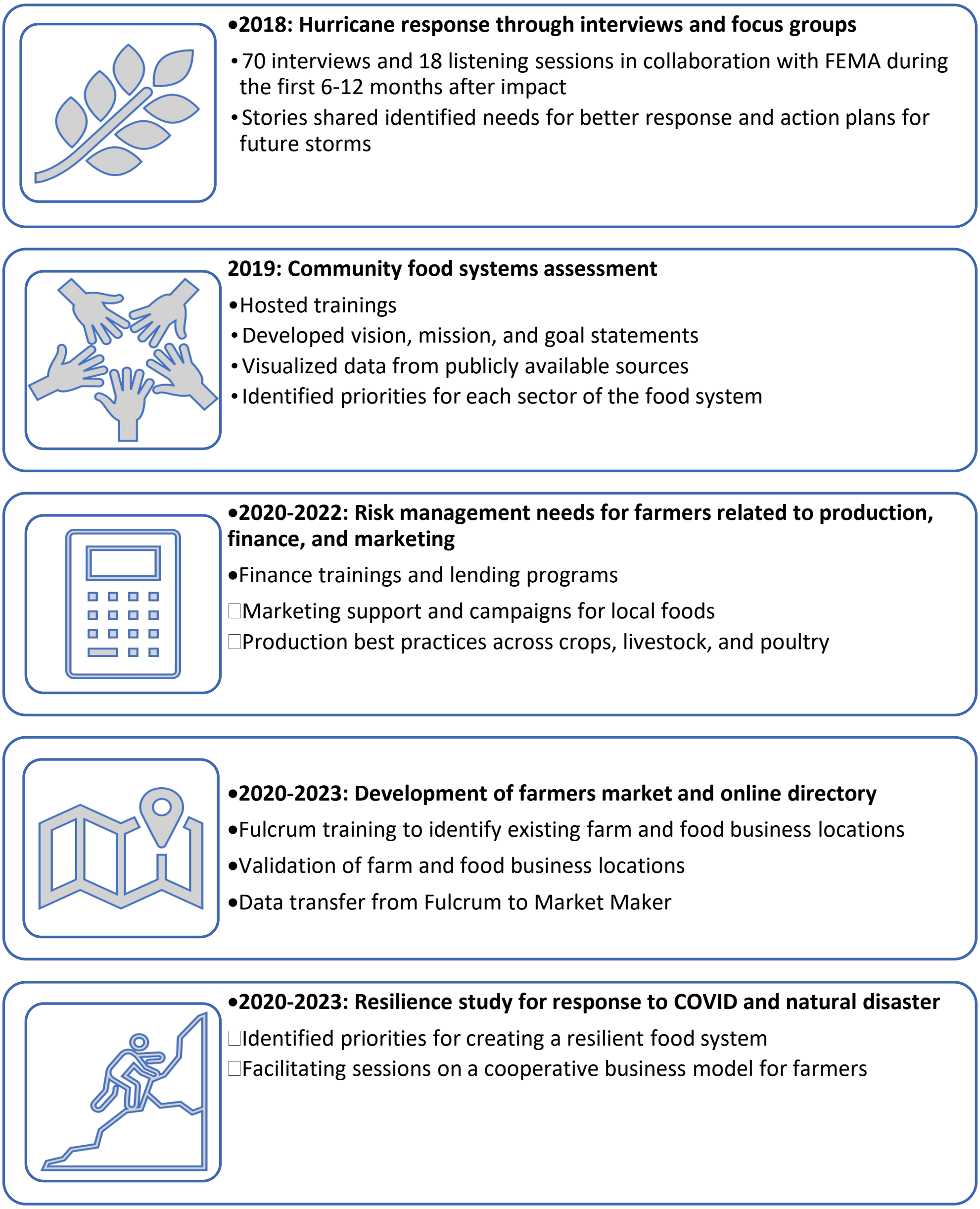

Fig. 2: Diagram showing a timeline of completed and ongoing activities in partnership with the U.S. Virgin Islands

3 Implementation of Digital Tools and Methods

Because the U.S. Virgin Islands has limited availability of up-to-date, detailed geospatial data, our initial priority was to create accurate maps of the islands following the 2017 hurricanes. This included identifying data sources to map features of the land and physical geography as well as infrastructure and the built environment. This built a foundation for understanding the spatial relationship between the landscape, land use and potential impacts to the food system from past and future hurricanes. To supplement the existing limited data, we utilized a combination of federal open data sources and OpenStreetMap (OSM). The data that was available through OSM was downloaded, analysed and visualized in QGIS. The initial maps produced were included in the 2019 community food systems assessment to showcase changes in the landscape, and to depict existing conditions after the hurricanes. While this may be a rudimentary procedure in some communities, it was a necessary step to establish a baseline inventory of existing farms within the built environment in order to move forward.

In 2020, we began work on the first component of creating an online farmers market by identifying interest, location and capacity of farms and food businesses in the Territory. While some data on the locations of food businesses can be found in OSM, there was no publicly available source that showed us the location of farms throughout the Territory. We needed a tool to aid in the creation and collection of this spatial data. The tool needed to be able to create point locations, attribute information and photos; and at the same time, handle the data collection challenges of unreliable internet and cell phone service, limited available funds and nontechnical users and data collectors. After a review of technology options, the mobile application Fulcrum was selected and utilized for this project.

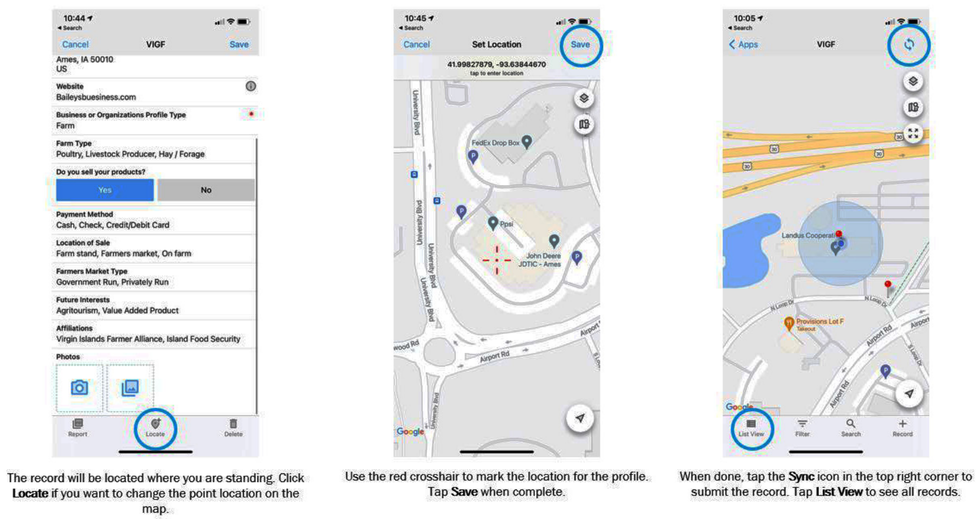

Fig. 3: Screenshots of the Fulcrum application with form questions utilizing conditional logic and feature allowing data collectors to identify the exact business location on the map

Fulcrum is a mobile application that is compatible with iOS and Android mobile devices and collects data using smart forms and GPS location. The Fulcrum platform is a simple option for nontechnical users who need to create geospatial data (points) with detailed attribute information. The forms are easy to create with a drag and drop functionality. The application can be deployed to multiple mobile device users and in field conditions where internet access is not available.

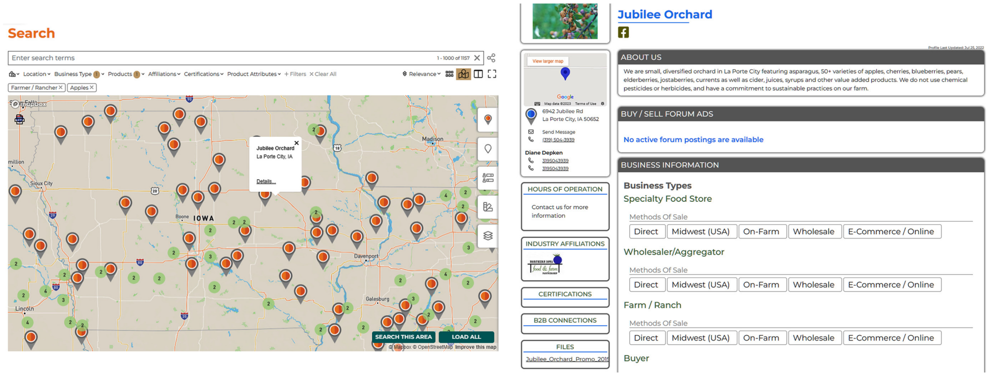

Fig. 4: Screenshots of the Market Maker platform, with view of apple farms in Iowa, and example business profile of an apple farm

With a tool selected, a standardized data collection form was created with 23 conditional questions in addition to the option to attach multiple site photos to each record. We worked with a U.S. food business directory platform, Market Maker, to create specific and detailed questions about the farm and food businesses related to products and business type. Questions ranged from standard contact information (name, email, phone number) to business or organization type, and specifics related to each business, such as type of product offered, sales options and affiliations. Our team designed the Fulcrum survey with conditional logic and visibility rules, along with single and multiple-choice form fields when possible (Fig. 3). For example, when asked, "What is your business or organization profile type?" individuals chose from ten different options. Based on their response(s), the next set of form questions populated and displayed. If a participant identified their business as a farm, the next question was about the type of farm. This logic continued throughout the form to keep the application streamlined and easy to follow. Another important feature of Fulcrum was that the default setting of using the location of the mobile device to collect the GPS location for the point record could be overwritten with a manual location selected from the displayed map. This feature was crucial for this project because data collectors could adjust the point marker position if they were not standing at the business store front during the verification and collection process.

As a starting point for populating data, the Virgin Islands Department of Licensing and Consumer Affairs provided a list of licensed farm businesses. This list gave us the business name, business owner and the business address for 294 licensed farm businesses in the Territory from 2020. From there, the business addresses were geocoded using Esri's ArcGIS World Geocoding Service and then imported into the Fulcrum platform (Fig. 5). This was another benefit of selecting Fulcrum: existing data could be imported into the form and utilize the subsequent data structure produced by the form. Utilizing existing farm business profiles, we hoped to be able to understand or visualize initial estimates of farmers across the Territory. However, we quickly learned that we did not have the ability to accurately locate the addresses because of the addressing system used within the Territory.

Due to address and geocoding constraints, we identified the need to connect with community leaders to help ground truth the information provided by the Department of Licensing and Consumer Affairs to accurately depict where farms and food businesses exist. This required community leaders to be trained to use the Fulcrum platform. Having previously used Fulcrum to support participatory mapping of community infrastructure for walkability, we knew the technology would work well for this situation (SEEGER 2015). We held three different training sessions and followed up with virtual technical assistance to teach best practices and to walk through the questionnaire flow. Participants were granted access to Fulcrum only after completion of the training sessions. To ensure data integrity, we utilized a validation method in Fulcrum so team members could track when profiles were completed.

Of the 294 farm business addresses provided, geocoding resulted in 40 % matched addresses, 50 % unmatched and 10 % tied match results. Unmatched and tied addresses were matched to the estate name when possible and the city name when not possible. This resulted in many addresses being located to the same position on the map, the centre of a town or estate. To deal with this, we utilized a data verification method in Fulcrum to tag points based on the location or attribute accuracy or validation level. Points with correct and verified attribute information but with inaccurate or unverified location information could be tagged as such. This method was used to help streamline the verification process.

Fig. 5: Map highlighting the challenge of geocoding addresses in the U.S. Virgins Islands. The triangle represents a validated farm address, collected using Fulcrum, while the lettered symbols represent the geocoding match candidates for the address supplied by Esri’s ArcGIS World Geocoding Service.

4 Results and Conclusions

There are currently 364 farms and food business records in the Fulcrum application. This includes the 294 provided, plus 70 additional farm and food businesses that have been added by trained data collectors. However, at this time, only 78 records have been fully validated through business information and data validation. During the Virgin Islands Agriculture Fair in February 2023, we will continue this process of validation. Once validated, business data records will be imported into the Market Maker system. This will increase opportunities for both consumers to find farm locations and products and for food businesses to find markets as well as maintain their business profiles. While this project and case study was not landscape site-based, it incorporates digital data collection techniques for meeting the unique challenges of this community.

Having a reliable platform for identification, sales options and connectivity creates a unique design application for investigating strategies in the broader food system. The process also allows for collaborators to identify next steps that will increase the resilience of the Territory's food system. Through data visualization, community dialogue and decision making, additional landscape design strategies have been identified:

- Support site-specific designs for on-farm solutions using best practices for resource management such as water access, conservation and production.
- Analyse Fulcrum data to understand key locations for aggregation and distribution of local foods. Site inventory and conceptual designs may be able to support the development of new food systems practices in the future.
- Discuss a regional food system design approach with key decision and policy makers. This may include aspects related to complex systems of food aggregation and distribution; best locations for farmers markets for consumer and farmer access; and increase in wholesale distribution through food cooperatives.

The development of a virtual farmers market platform will not only serve as a mapping resource of existing farms and businesses but will also provide an opportunity for increased sales and new market options across the Territory. Individual farmers will have the ability to sell their products through the platform and work with consumers to negotiate a preferred pick-up location, whether at an existing farm store or another drop off site. Additionally, this application will include a customer interface that allows for individuals to both identify and locate farms selling local products, and purchase from them. It is believed that this new market will provide an added value and opportunity for farmers, and increase interest in producing local food, leading to a more resilient and diversified environment. The team anticipates that consumers in the Territory, as well as tourists, will better be able to access, gain knowledge about local products and increase direct to consumer sales. However, the community will need to continue to foster awareness, marketing and additional supports for their local and regional food businesses.

By understanding existing conditions, we can better prepare and determine appropriate resilient strategies for rebuilding (LONG et al. 2019). This case study highlights the transferability and connection between mapping, inventory analysis, and use of Fulcrum to collect primary data in a community with limited internet and geospatial technology capacity. Opportunities to further connect with the government to streamline and digitize procedures, such as the farmer licensing form, may be an opportunity to improve data collection. There is further work to be done to foster local food production, business and finance best practices, and consumer awareness about local foods. These initial steps towards creating a virtual farmers market framework and leading to a digital platform establish a baseline critical to move forward in the process. We suggest future explorations use the improved geospatial data created in this project to develop site-, community-, and regional scale solutions related to the Territory's food system.

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