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How Much, How Big, and Where? Determining an Optimal Supply Chain Network for Locally Grown Blueberries Using a Facility Location Model

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Abstract

Strategic siting of production areas, aggregation hubs, and distribution routes at the regional level is essential to coordinate supply and demand for local food and establish an efficient food supply chain. This study examines the least-cost supply chain network for distributing locally grown fresh blueberries in Georgia using a geospatial optimization model. Three demand scenarios were evaluated, incorporating production sites, food hub capacities, distribution center locations, road infrastructure, and transportation modes. Results show that smaller food hubs located near production fields minimize costs under the travel distance constraints. More miles are traveled from food hubs to retail centers than from production sites to food hubs. Producers near retail markets hold a comparative advantage. To develop a least-cost local blueberry distribution system in Georgia, public support may prioritize locating food hubs closer to farms and reducing food hubs' outbound transportation costs.

Keywords: facility location, food hubs, investment, local food, supply chain

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Introduction

Over the past few decades, interest in local food systems has been growing among consumers, policy makers, and the fresh produce industry. This trend reflects a broader movement toward sustainable sourcing, regional economic development, and environmental and healthy food conscious consumption (Ethoven and Van den Broeck, 2021). In the United States, sales of local food reached $17.5 billion, a 33.2% increase from 2017 (USDA-NASS, 2022a). Sales of local food are expected to increase as U.S. consumers increasingly prefer fresh fruits and vegetables sourced from local farming systems (Center for Food Demand Analysis and Sustainability, 2025).

Strategic coordination across production, aggregation, and distribution is essential, particularly for enabling small and medium-sized farms to participate in local and regional food systems (Berti and Mulligan, 2016). Compared to long and complex industrialized food supply chains, local food supply chains are typically shorter, involve fewer intermediaries, and depend more heavily on regional infrastructure and logistics efficiency of individual participants (Marsden, Banks, and Bristow, 2000). Local food supply chains can also cooperate or coexist with conventional food supply chains, such as by selling local products in supermarkets (Thomé et al., 2021).

The U.S. federal and state governments have made significant and sustained investments in programs supporting local and regional food system development. For instance, in 2024, the U.S. Department of Agriculture (USDA)'s Local Agricultural Market Program (LAMP) awarded more than $43 million to 113 projects across the United States. However, these projects emphasize training, technical assistance, and community development. Relatively less funding is allocated to strategic supply chain planning or network configurations, although the need for economic feasibility, location, and capacity research on food hub investment and financial support for scaled-up local food distribution system development is widely recognized in many states (Hellwinckel and Velandia, 2016; Furman et al., 2018; Murphy, 2025).

Insufficient infrastructure and supply chain configurations may discourage many small and mid-sized farmers from participating in local food systems (Kinnunen et al., 2020). Research shows that distribution and transportation could account for more than 30% of total expenses for U.S. producers participating in local food systems (Martinez and Park, 2021), and small and mid-sized producers generally prefer not to travel long distances to access local markets (Kremer and DeLiberty, 2011; Bobronnikov, Prenovitz, and Yadav, 2019). Food hubs have emerged as a critical intermediary in this landscape to improve market access for small and medium producers (Low et al., 2015). Food hubs are also important for efficiently handling perishable fruits and vegetables, where cold storage and timely movement through the supply chain are required. According to the 2021 National Food Hub Survey, more than 80% of surveyed hubs engaged in "buy local" promotion efforts, and more than half of their sales revenue derived from direct marketing channels (Bielaczyc et al., 2023). Nonetheless, transportation costs remain a significant constraint, especially for small-scale hubs operating with limited capacity and geographic flexibility.

From a business perspective, the capacity and location of food hubs are critical factors for achieving optimal operations and long-term financial sustainability (Matson and Thayer, 2013).

Many food hubs initially rely on government or institutional funding and grants, with the expectation of becoming economically self-sufficient within three to five years. Once established, a food hub operates much like a new business venture. Without sufficient participation from local farmers or other suppliers, the facility and its services may not be economically viable. Although the "if you build it, they will come" model may succeed in some areas, it can fail in others, as demonstrated by unsuccessful grocery store interventions in some underserved neighborhoods, where low profit margins and high overhead costs undermined efforts to improve access to healthy food (Engler-Stringer et al., 2019). Many food hubs also failed due to not having enough producers (supply) or buyers (demand) to reach profitability (George, 2016; Feldstein and Barham, 2017).

Regional level strategic siting of production areas, aggregation hubs, and distribution routes is essential to ensure the coordination of supply and demand for local food and establish efficient supply chains (Dimitri and Gardner, 2019; Paciarotti and Torregiani, 2021). Logistics is the first key step (Maciejczak, 2014; Rucabado-Palomar and Cuéllar-Padilla, 2020). Optimized logistics ensure sales can happen at a specific location and consistently meet customer expectations regarding food item selection, quantity, quality, and packaging. Food producers learn about consumer demand (preferences and prices) through direct and indirect communication, such as orders, invoices, and customer complaints. Transportation and distribution infrastructure support logistics and communications of the supply chain, including i) connectivity of local and regional road networks between food production sites and the consumption; ii) producers' accessibility to intermediaries that are equipped to handle and have the storage capacity for perishable food items; and iii) appropriate transportation modes, such as truck size and type, for different travel distances and volumes. Simulation and/or optimization methods can be used to investigate the best local food supply chain network design that serves multiple local food producers and intermediaries and saves costs within specific communities or local regions (Tundys and Wiśniewski, 2020; Paciarotti et al., 2022; Bayir, Charles, and Ouzrout, 2024).

This study examines a least-cost supply chain network for locally grown fresh blueberries in Georgia using a geospatial optimization model. The model incorporates production locations, infrastructure constraints, food hub capacities, and multiple demand scenarios to identify cost-minimizing network configurations among farms, food hubs, and retail distribution centers. A sensitivity analysis on yield is conducted to capture the effects of output variability on the network.

Study Region

The study region is the state of Georgia. Georgia has 159 counties and a diverse agricultural economy. More than 75% of its counties are considered rural. Most of these rural counties are in the southern half of the state. Blueberry production in Georgia was initially adopted as a profitable alternative crop following the phase-out of tobacco production. Driven by growing consumer demand for blueberries and a decline in peach demand, blueberries are now the top fruit commodity produced in Georgia (Powers, 2023; Chu and Williams, 2025). In 2021, Georgia's blueberry industry contributed more than $348 million to Georgia's economy compared to $85 million from the peach industry (Powers, 2023; University of Georgia, 2023). The majority of Georgia's bearing acreage is planted in rabbiteye blueberries (*Vaccinium Ashei*), with increasing

acreage in southern highbush cultivars (*Vaccinium corymbosum* hybrids) in the past decade (Chu and Williams, 2025). These varieties are well-suited to the state's climate and support Georgia's early-season market window. Growers coordinate their efforts through marketing cooperatives and industry associations, including the Georgia Blueberry Grower Association and MBG Marketing. Public research institutions, such as the University of Georgia Cooperative Extension, contribute to industry advancement through cultivar development and the dissemination of science-based production practices. The Georgia Blueberry Commodity Commission supports research and promotional initiatives and helps align growers with markets.

In 2023, Georgia ranked as the third largest blueberry producing state in the United States, contributing about 15% of the total utilized production (USDA-NASS, 2022b). Georgia's total blueberry acreage reached 17,800 acres in 2020, 19,300 acres in 2021, 16,800 acres in 2022, and 21,400 acres in 2023 (USDA-NASS, 2022b). Most of Georgia's blueberries are produced in the southern region. Around 90% of its blueberry acreage is located in Appling, Bacon, Clinch, Pierce, Wayne, and Ware counties, where sandy soil is ideal for blueberry production. There are also small producers primarily growing for local markets or pick-your-own operations throughout the state. Many of these small producers are located in the northern region, where there is a higher population density.

Although Georgia blueberry growers are actively seeking to expand their export markets to reach international consumers (Eastfruit, 2023; Yeh et al., 2023), there is untapped potential to further develop the local markets as well. With increasing consumer interest in locally sourced fresh produce, growers have an opportunity to meet the demand for blueberries within Georgia. Approximately 2 million Georgia residents currently reside in areas classified as low-income and low-access to food within 10 miles (USDA-ERS, 2025). Tariffs imposed under the 2025 Trump administration will not affect fresh produce from Canada and Mexico under the United States-Mexico-Canada Agreement. However, future uncertainty in tariff changes may be disruptive to imported blueberries from other countries. This tariff uncertainty could present an opportunity for Georgia blueberry producers to expand their supply to local markets. In addition to farmers' markets and pick-your-own farms, integrating the state's blueberry supply chain with the existing supermarkets can balance efforts to grow both export and local markets and help to create a more resilient and diversified demand for Georgia's blueberry industry.

Facility Location Model and Data

This study models the distribution of fresh blueberries in Georgia as a facility location problem. Blueberries move from production fields to food hubs, where they are aggregated and temporarily stored, and then to retail distribution centers (see Figure 2). Distribution efficiency depends mainly on transportation costs along these routes.

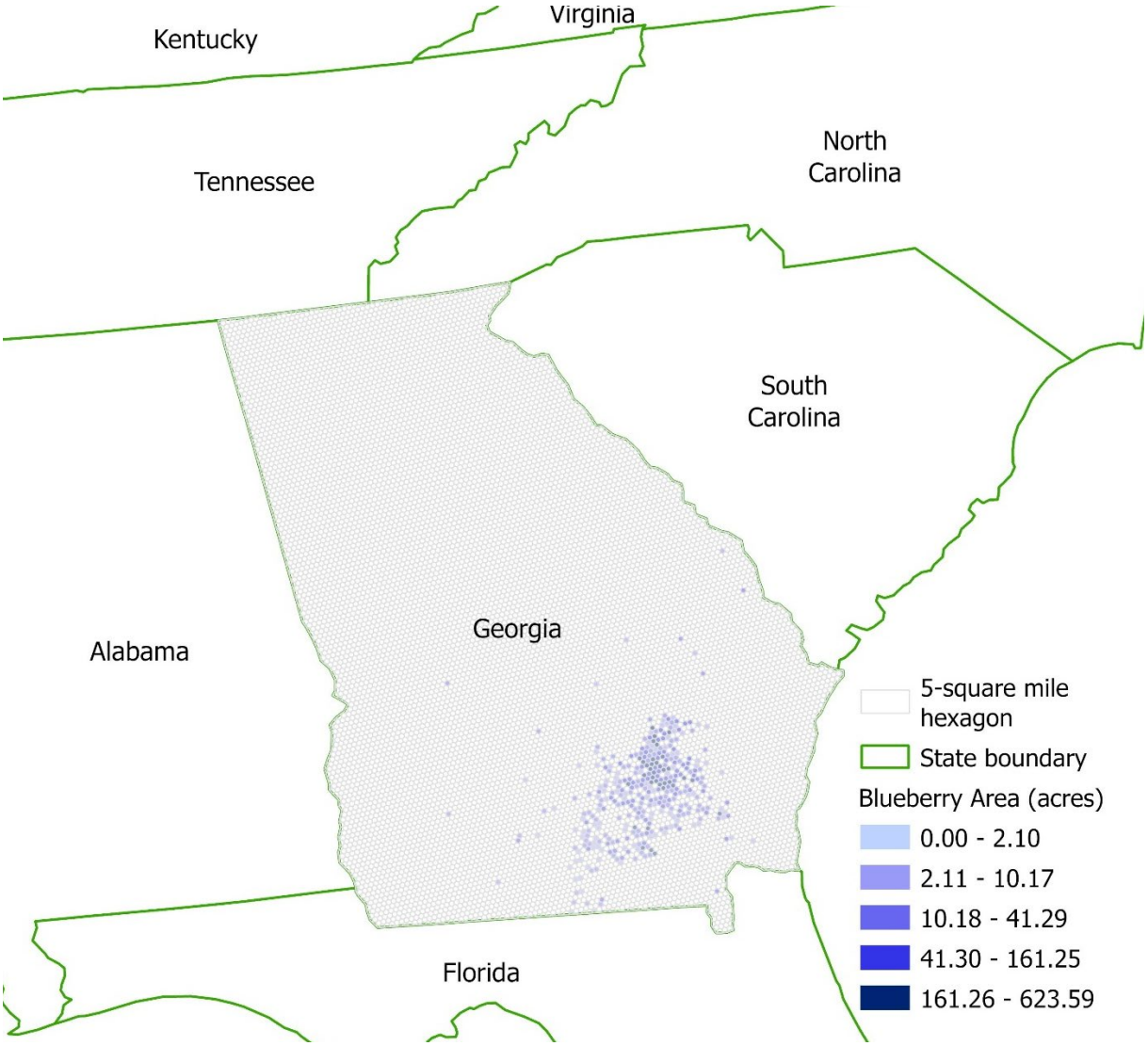


Figure 2. Georgia Blueberry Production Location and Acreage

We use network design theory to identify a cost-minimizing distribution system that meets consumer demand. The model minimizes total system costs by selecting the number, location, and capacity of food hubs, given the existing locations and production levels of blueberry fields, distance limits, and transportation infrastructure. Because food hub decisions directly affect farmers' transportation costs and the amount of production needed to supply local markets, this problem fits the classic facility location framework. The model addresses three main questions: (i) how many food hubs are needed, (ii) where they should be located and at what capacity, and (iii) how blueberry flows should be allocated among fields, food hubs, and retail distribution centers.

There are various types of facility location problems with different measurements of effectiveness of a facility location (Drezner and Hamacher, 2001; Melo et al., 2009). One way to measure a facility's effectiveness is the average distance or time that products or services must travel from a facility to the end users. In 1964, Hakimi (1964) introduced the *p*-median problem. He called a set of p points (facilities) as "medians of the network" if the set of points (facilities) results in a minimum total weighted distance between facilities and product demand nodes. The objective of a *p*-median problem is to minimize the sum of the weighted distances between facility and demand points, subject to a fixed number of facility locations given a distance matrix and candidate locations. The number of facilities is predetermined, but the location of facilities is endogenous. The *p*-median problem can be expanded to include more realistic constraints, such as the maximum travel distance from the facility to customers (Khumawala, 1973) and consideration of transportation and facility setup costs (Baumol and Wolfe, 1958; Balinski, 1965). The Capacitated Facility Location Model (CFLM) is an extension of the *p*-median problem and has been considered one of the most important location models used extensively by public organizations and private industries (Farahani and Hekmatfar, 2009). The CFLM aims to determine an optimal set of capacitated facilities such that the sum of facility construction and transportation costs is minimized. The mathematical formulation of the CFLM is a mixed integer linear programming (MILP) problem with facility locations entering the solution as binary variables.

Mixed Integer Linear Programming (MILP) Model

A Mixed Integer Linear Programming (MILP) model was developed to identify optimal blueberry supply chain network configuration that minimizes the total of food hub establishment costs and transportation costs (see equation 1), subject to a set of constraints on supply, demand, shipping routes, and candidate food hub site locations. Table 1 provides the nomenclature of the model.

Table 1. Nomenclature of the Indices, Variables, and Parameters of the Optimization Model

Index	
i	the location of production field, $i = 1, \dots, 361$
j	the candidate location for food hubs, $j = 1, \dots, 206$
k	the location of retail distribution center, $k = 1, \dots, 36$
m	food hub capacity options, $m = 1, \dots, 3$
Variables	
x_i	area harvested in i to meet the local blueberry demand
z_{jm}	is a binary variable 0 when the food hub candidate location is not selected; 1 selected
v_{ij}	volume of blueberries shipped from production site i to food hub j (tons)
u_{jk}	volume of blueberries shipped from food hub j to demand location k (tons)
Parameters	
Y_i	yield of blueberry in i (ton per acre)
A_i	total blueberry cultivation areas in field i (acres)
G_m	volume can be stored and processed in food hub with capacity m (tons)
D_k	demand of blueberry in location k (tons)
r	percentage of total demand for blueberries fulfilled by local supply (%)

Table 1 (cont.)

Parameters	
H_m	Unit cost for food hub at capacity m (\$ per unit)
c_{ij}	unit costs of transportation from i to j (\$ per ton-mile)
c_{jk}	unit costs of transportation from j to k (\$ per ton-mile)

The objective function is:

$$Minimize\ \ CF + CT \tag{1}$$

where

CF: total food hub establishment costs (\$)

CT: total transportation costs (\$)

Total food hub establishment costs, CF, is the sum-product of a binary variable, z_{jm} and H_m, the establishment cost of food hub facility with capacity m (see equation 2). The binary variable, z_{jm}, denotes the selection of storage location j and its associated capacity type m.

$$CF = \sum_m \sum_j z_{jm} \cdot H_m \tag{2}$$

The transportation cost, CT, includes transportation from production field i to food hub location j and then from food hub j to distribution center k (see equation 3). The unit cost of delivering blueberries from production field i to food hub j is c_{ij}, and the shipment volume between i and j is v_{ij}. The total cost of transporting blueberries from production field to food hub is the sum-product of unit shipment costs c_{ij} and the shipment volume v_{ij}. The total cost of transporting blueberries from food hub j to distribution center k is the sum-product of unit cost c_{jk} and the shipment volume from j to k (u_{jk}).

$$CT = \sum_i \sum_j v_{ij} \cdot c_{ij} + \sum_j \sum_k u_{jk} \cdot c_{jk} \tag{3}$$

Given the limitation of information availability on site-specific fields and post-harvest operational costs, we have assumed homogenous blueberry production, packaging, and marketing costs across each location i. Therefore, they are not considered in the objective function.

Equations 4–8 are model constraints. The blueberry areas harvested to meet the local food demand in field i, x_i, should not exceed the total available blueberry area in i, A_i (see equation 4). The total shipment volume of blueberries from field i to food hub, $\sum_j v_{ij}$ is determined by harvesting area x_i and yield Y_i (see equation 5). The receiving shipment from all i to specific j should not exceed j's capacity (see equation 6). Equation (7) shows that the amount of blueberries shipped from food hub j to retail distribution center k should not exceed the amount shipped into j from production fields.

$$x_i \leq A_i \quad (4)$$

$$\sum_j v_{ij} = x_i \cdot Y_i \quad (5)$$

$$\sum_i v_{ij} \leq \sum_m G_m \cdot z_{jm} \quad (6)$$

$$\sum_k u_{jk} \leq \sum_i v_{ij} \quad (7)$$

Not all demand for fresh blueberries will be met by local production. We assume that only a certain percentage (r) of the total demand in location k, D_k, will be supplied by local production. The amount of shipment from food hub j to retail distribution center k should at least be $D_k \cdot r$. (see equation 8).

$$\sum_j u_{jk} \geq D_k \cdot r \quad (8)$$

Data

Unit of Analysis and Production Areas and Yields

The state of Georgia was digitized into 5-square-mile hexagons using ArcGIS (see Figure 1). These polygons are the functional "decision making units," determining the nodes along optimal transportation pathways. Potential blueberry areas that can be harvested to meet local demand, food hub candidates that distribute locally grown blueberries, and retail distribution centers are identified at the hexagon level.

The blueberry production area and location data are from DTN, a U.S.-based data analytics and information services company that specializes in agriculture, weather, energy, and transportation sectors (https://www.dtn.com/). In this research, DTN data were aggregated and superimposed on 5-square-mile hexagons to identify blueberry production areas in each hexagon (see Figure 1).

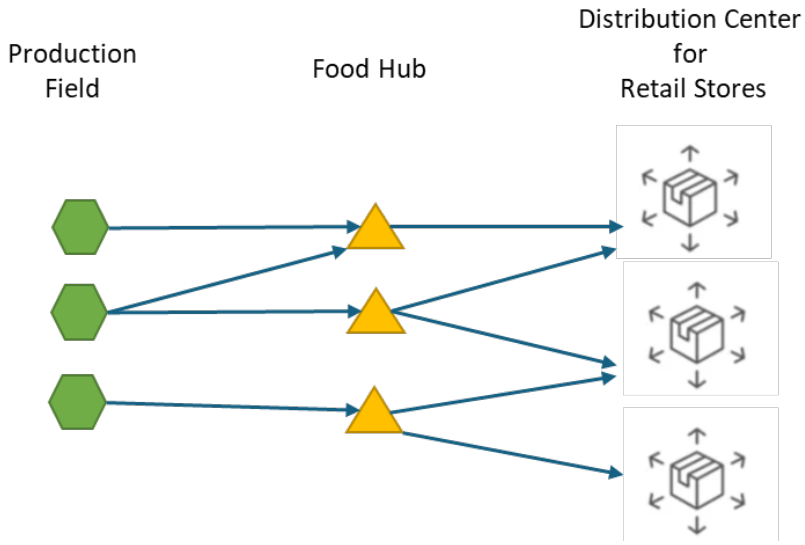


Figure 1. Structure of Modeled Supply Chain

Blueberry yield is assumed to be 4,200 lbs per acre in the baseline. This is the average yield of Georgia blueberries in 2021 (USDA-NASS, 2022b). Blueberry annual yields are affected by various factors, such as weather conditions and plant age (Retamales et al., 2015). To account for the yield uncertainty, we conducted a sensitivity analysis by reducing yields from the baseline level to 70% of the baseline in 5% increments (see Table 2).

Table 2. Yield Scenarios

Yield Scenarios	Description	Value (lbs per acre)
Y100	baseline yield	4,200
Y95	95% of baseline yield	3,990
Y90	90% of baseline yield	3,780
Y85	85% of baseline yield	3,570
Y80	80% of baseline yield	3,360
Y75	75% of baseline yield	3,150
Y70	70% of baseline yield	2,940

Food Hub Candidate Locations and Costs

We used 260 geographic locations of existing warehouses for vegetables and fruits in Georgia as the candidate food hub locations that can be used to serve, gather, and store locally grown fresh blueberries before transporting them to retail distribution centers (see Figure 3[a]).[1]

Three capacities were considered for food hubs, including 50 tons per year (small), 100 tons (medium), and 500 tons (large). Accurately determining the food hub establishment costs for different capacities is challenging. Establishment costs vary by location, construction or renovation requirements, specialized storage and handling equipment, labor and permitting requirements, and necessary utilities or site upgrades. The uncertainty of these factors makes standardized cost estimates difficult. To differentiate costs by hub capacity for modeling purposes, we assume a small 50-ton food hub requires an initial investment of $250,000. This number is based on the total fixed costs reported for a representative food hub case study in the USDA-RDS (2018) report "*Running A Food Hub: Assessing Financial Viability*." The establishment costs for a medium-sized 100-ton food hub and a large 500-ton food hub are assumed to be $500,000 and $2.5 million, respectively, based on proportional scaling of capital requirements.

Proxy of Retail Distribution Center Locations

We used the centroids of metropolitan and micropolitan statistical regions located in Georgia as the proxy of retail distribution center locations (see Figure 3[a]). The U.S. Office of Management and Budget defines metropolitan and micropolitan statistical regions. A metropolitan statistical area has at least one urban area with a population of 50,000 or more. A micropolitan statistical

[1] Data from Mergent Online: https://www.mergentonline.com/basicsearch.php [Accessed January 9, 2023].

region is a smaller region with at least one urban area of 10,000 to 49,999 people. Figure 3(b) presents the population density in 35 metropolitan and micropolitan regions overlaying the state.

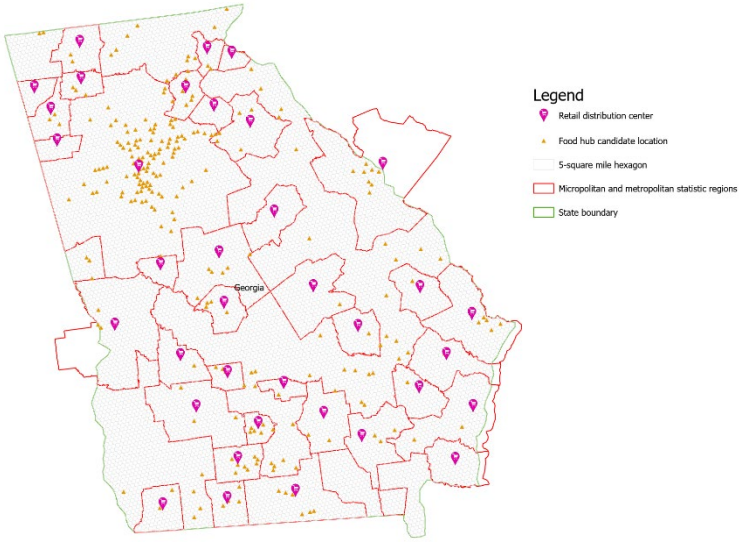


Figure 3a. Candidate Locations of Food Hubs, Centroid of Metropolitan and Micropolitan Statistic Areas in Geogia

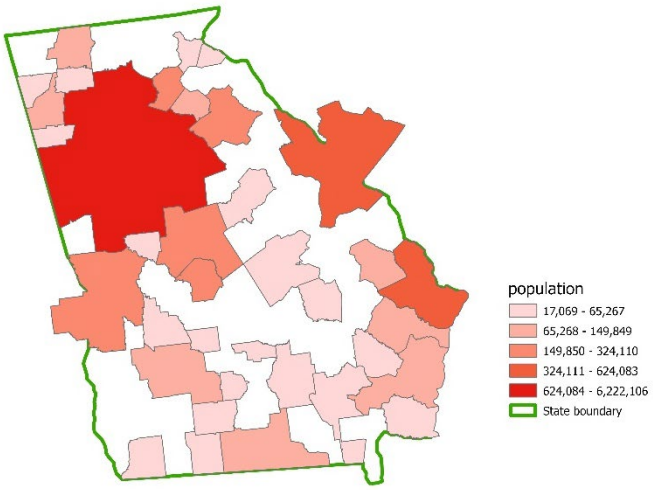


Figure 3b. Population Density in Metropolitan and Micropolitan Statistic Areas

Transportation and Costs

A distance matrix was generated between hexagons using ArcGIS based on the existing road network. The maximum allowable travel distance between production field hexagons to food hub hexagons was 50 miles. The distance assumption is based on the 2013 USDA-FNS Farm to School Census (USDA-FNS, 2015), which reported that 20% of respondents defined local food as produced within a 50-mile radius (Bobronnikov, Prenovitz, and Yadav, 2019). Kremer and

DeLiberty (2011) also found that the median travel distance for small- and medium-sized farmers to farmers' markets was 57 miles. The maximum allowable travel distance between a food hub and a retail distribution center was 400 miles. This distance assumption follows the 2008 Farm Bill that defines the "locally or regionally produced agricultural food product" as the product is transported less than 400 miles from the origin of the product or the State in which the product is produced (Food, Conservation, and Energy Act of 2008, Pub. L., 110-246, 122 Stat. 1929).

We include two truck types with capacities of 4 and 8 tons to represent transportation modes. The 4-ton truck reflects smaller vehicles used for farm to hub and short distance deliveries, while the 8-ton truck represents larger medium-duty trucks used for aggregated shipments from food hubs to retail centers. According to the USDA's Agricultural Refrigerated Truck Quarterly, transportation costs for southeast local routes (under 500 miles) averaged $6 per mile in the second quarter of 2022 (AgRTQ Datasets, n.d.). This translates to $1.50 per ton-mile for a 4-ton truck and $0.75 per ton-mile for an 8-ton truck. For each mile traveled, the cost of transporting an additional ton is lower with the 8-ton truck than with the 4-ton truck.

Demand Scenarios

The USDA-ERS (2016) estimates U.S. per capita consumption of fresh blueberries at 1.76 pounds. This measure includes both domestically produced and imported berries. Regional demand is calculated by applying this per capita consumption value to the metropolitan and micropolitan populations. Although more recent non-USDA sources suggest higher per capita consumption levels in the 2020s, ranging from approximately 2.3 to 2.7 pounds per capita according to trade publications and industry analyses (e.g., USDA-NASS, 2020; Hammami et al., 2024; Karst, 2024), we rely on the USDA estimate for consistency and reliability.

Demand scenarios are based on the percentage of fresh blueberries demand to be fulfilled by local supply in each metropolitan and micropolitan region. Table 3 shows the demand scenarios, including DM-5% (5% of the total demand to be fulfilled by locally grown products), DM-10% (10% of the total demand to be fulfilled by locally grown products), and DM-20% (20% of the total demand to be fulfilled by locally grown products). The total targeted demand volume for the state fulfilled by local supply is 455 tons, 910 tons, and 1820 tons, respectively.

Table 3. Demand Scenarios

Demand Scenarios	Description	Total Targeted Demand Volume from Local Supply (Tons)
DM-5%	5% of the demand for fresh blueberries fulfilled by local supply	455
DM-10%	10% of the demand for fresh blueberries fulfilled by local supply	910
DM-20%	20% of the demand for fresh blueberries fulfilled by local supply	1,820

Software and Solver Routine

The model was programmed in the GAMS (General Algebraic Modeling System) optimization package. The models were solved using the commercial solver CPLEX 10 on the GAMS platform. The relative gap was set to be less than or equal to 0.5%.

Results

Optimal Solution on the Network Configuration

The optimal network configuration includes the location and area harvested, the location of the food hubs, and the retail distribution centers that are served. Figure 4 shows the location and area harvested to fulfill demand for locally grown fresh blueberries under the baseline yield level (4,200 lbs per acre) and different demand scenarios. When the demand is small (i.e., DM-5%), 14 hexagons are identified to supply blueberries to meet the demand at each retail distribution center. The total area harvested to meet the demand is about 213 acres, with a minimum of 5 acres and a maximum of 23 acres per hexagon. Under the DM-10% scenario, 17 hexagons are identified, with a minimum of 0.5 acres and a maximum of 234 acres. The total area harvested is 426 acres, which is linear to the demand because of the homogenous yield assumption in the model. In reality, the yield could be different among these hexagons. The identified number of hexagons reached 20 as the total demand increased to 1,820.43 tons (total acres harvested were 468) under the scenario DM-20%. Most of the harvested areas are located in the southern Georgia major blueberry production region.

Given that demand equals supply, the model always serves all the retail distribution centers. The model identifies food hubs that are within a 50-mile radius of the supply hexagons and a 400-mile radius of the retail distribution centers. The maps of the supply network, from harvesting hexagons to food hubs and from food hubs to retail distribution centers, are presented in Figure 4 for alternative demand scenarios. Most of the food hubs are proximate to the blueberry fields located in the southern part of the state, although most of the candidate food hub locations are located in the northern part of the state, closer to the centroid of the metropolitan and micropolitan regions (see Figure 3[a]). Between production fields and food hubs, smaller trucks require more frequent trips to move the same volume. Locating food hubs near production fields can reduce the total travel distance between fields and food hubs, thereby reducing transportation costs. This result is similar to Ge et al. (2025)'s research in Georgia for identifying the optimal solution for fresh produce food hubs in the United States.

In the DM-5% scenario, 10 food hub locations are selected, each with a capacity of 50 tons (see Figure 5, at Y100). Smaller hubs located close to harvest fields minimize short-haul transportation costs from fields to hubs. When the demand increased to DM-10%, the total number of food hubs remained 10, but with one hub having a capacity of 100 tons. Compared to DM-5%, the model expands capacity at one location from 50 to 100 tons. Under the higher demand scenario DM-20%, the number of food hubs increased to 14, with 9 locations having 50 tons capacity, two locations having 100 tons capacity, and three locations having 500 tons capacity. At this demand level,

increasing hub size is no longer enough. Shipping blueberries over long distances from only a few hubs becomes costly. The model chooses to open more hubs and to build some hubs with a much larger capacity (500 tons). Most of these selected food hubs tend to be placed close to, or at, harvest field locations (hexagons) to keep transportation costs low.

Transportation Miles

Table 4 presents the miles traveled under different demand scenarios. In general, the miles traveled from field locations to food hub locations are much shorter than those from food hub locations to retail distribution centers, due to the shorter travel distances between fields and food hubs. When demand is low, DM-5%, the total miles traveled from field to food hub is about 2,166 miles, whereas the miles traveled from food hubs to retail distribution centers are 14,982 miles. In the demand scenario DM-20%, the miles traveled between food hubs and retail distribution centers could reach 69,384. Higher demand may not necessarily result in much higher travel miles from field to food hub, but it could double or triple the miles traveled from food hubs to retail distribution centers due to a much larger travel radius allowed by the model. The results show that outbound transportation costs for food hubs could become dominant as demand grows, potentially reducing food hub profitability.

Table 4. Miles Traveled under Different Demand Scenarios and Baseline Yield

Scenarios	Field to Food Hub (Miles)	Food Hub to Retail Distribution Center (Miles)
DM-5%	2,166	14,982
DM-10%	3,339	32,322
DM-20%	3,796	69,384

Note: DM-5%, DM-10%, and DM-20% represent cases where 5%, 10%, and 20% of total demand is met with locally grown blueberries, respectively.

Sensitivity Analysis on Yield

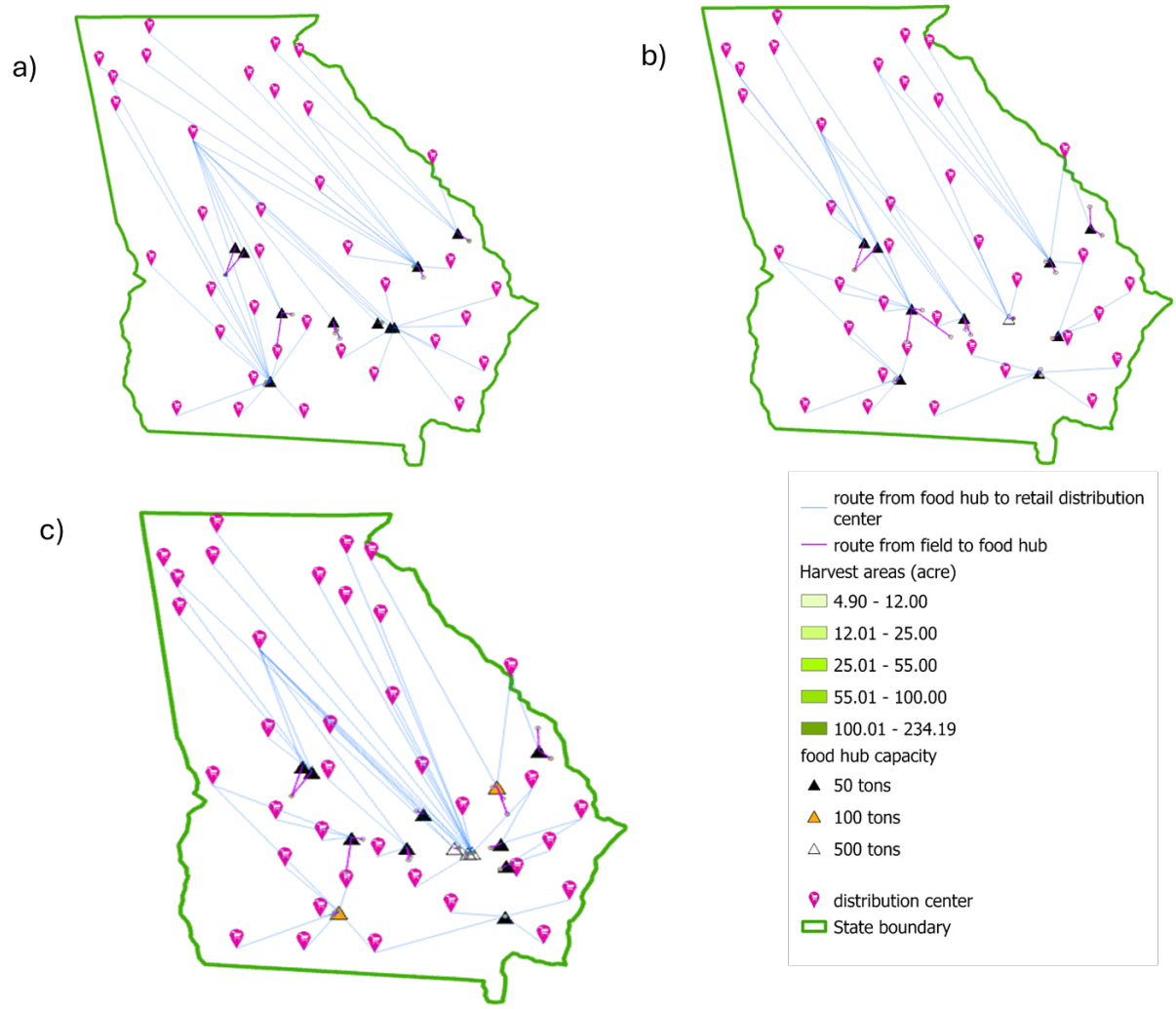


Figure 4. Solutions under Different Demand Scenarios and Baseline Yield (Y100)

Notes: a) DM-5% where 5% of the total demand to be fulfilled by locally grown products; b): DM-10% where 10% of the total demand to be fulfilled by locally grown products; c): DM-20% where 20% of the total demand to be fulfilled by locally grown products. Harvest area refers to area harvested to meet fresh blueberry demand in Georgia.

Decreasing blueberry yields affect the optimal solution for the number and capacity of food hubs. As shown in Figure 5, the number of food hubs increased when the yield is low, with the lower capacity hubs (50 tons) dominating in the network. Whereas the number of 500-ton hubs remained relatively stable, the smaller hubs are needed to aggregate dispersed supply under reduced yield scenarios. Lower yields reduce the amount of blueberries produced in each hexagon with existing fields. To meet the same level of total demand, blueberries must be collected from more hexagons (i.e., more producers) that are spread over a wider area. This practice expands the supply network and increases the need to coordinate across many locations. As a result, lower blueberry

productivity may put more pressure on decentralized infrastructure and may require additional investment in small-scale food hubs to aggregate production.

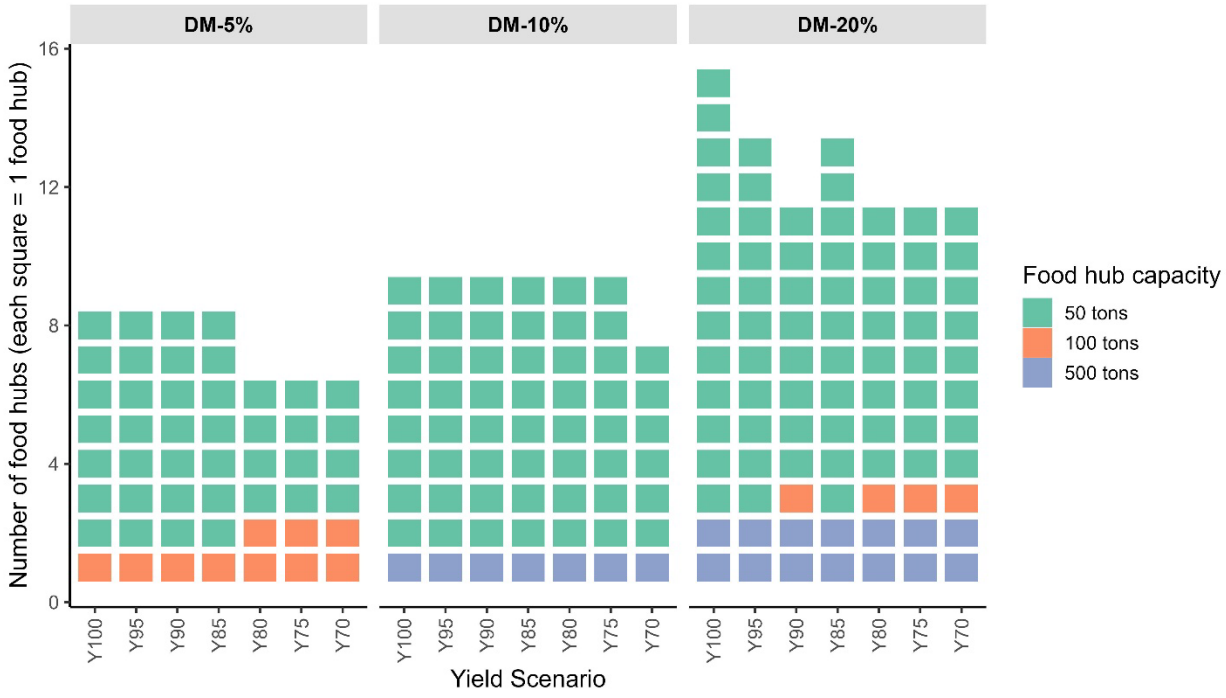


Figure 5. Food Hub Number and Capacity under Different Levels of Yield and Demand Scenarios

Notes: DM-5%, DM-10%, and DM-20% represent cases where 5%, 10%, and 20% of total demand is met with locally grown blueberries, respectively. Y100 denotes the baseline yield level, while Y95 through Y70 represent 95% to 70% of the baseline yield.

Figure 6 shows the total distance traveled under each yield and demand scenario, plotted on a log-transformed scale. As yields decrease, both short-haul (field to hub) and long-haul (hub to retail) transportation distances increase, especially under the DM-10% and DM-20%. The growing share of short-haul distances at lower yields is due to the spatial dispersion of supply sources.

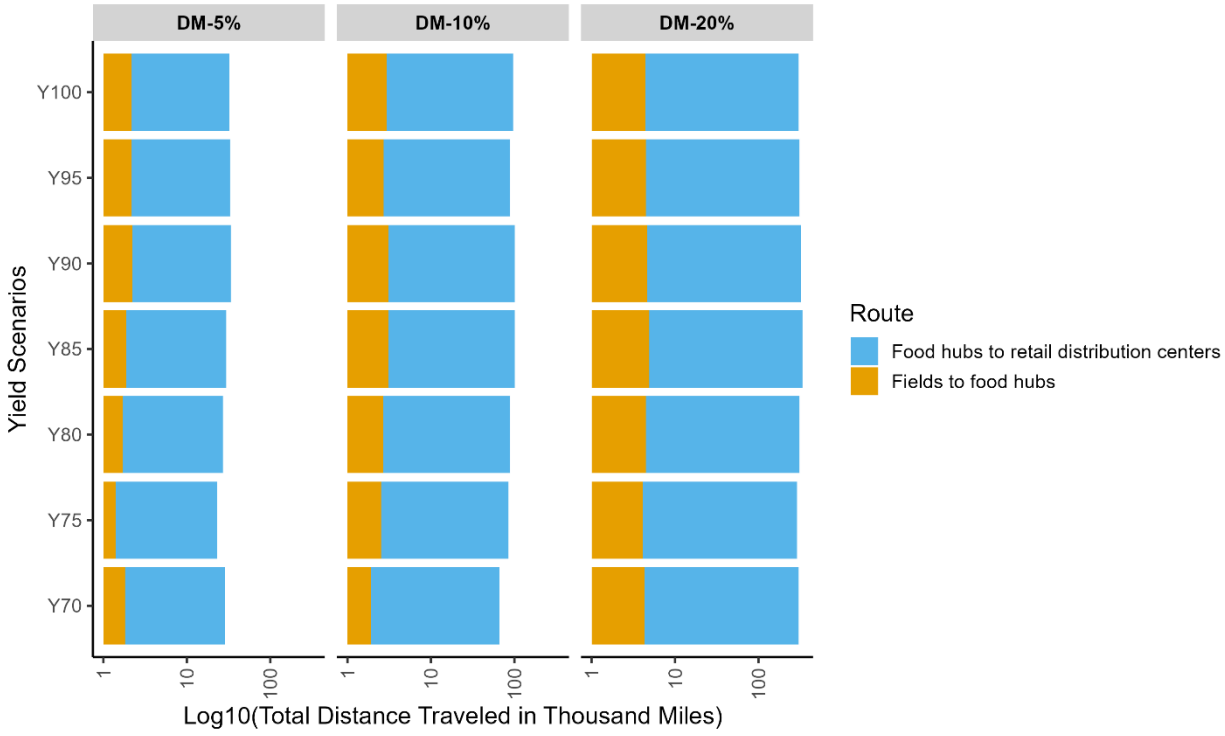


Figure 6. Logarithms of Total Travel Distance under Different Demand and Yield Scenarios

Notes: DM-5%, DM-10%, and DM-20% represent cases where 5%, 10%, and 20% of total demand is met with locally grown blueberries, respectively. Y100 denotes the baseline yield level, while Y95 through Y70 represent 95% to 70% of the baseline yield.

Conclusions

The local food movement has gained widespread support, but questions remain about how to effectively scale it up for small and medium-sized farms interested in supplying local consumers through food hubs. Given that the local food supply chain is still emerging and lacks an established operational structure, *ex post* empirical analysis is not an ideal approach. Instead, *ex ante* research or design work has comparative advantages for specifying and optimizing the system's potential configuration (King, 2012; Zilberman, Kozler, and Yan, 2025).

This research presents a case study of Georgia blueberries to demonstrate how location theory can inform strategic planning for regional local food system development. Although only food hub investment and transportation costs were considered, the findings provide insights into Georgia's supply, demand, and infrastructure for local blueberry distribution. When demand is limited and yields are high, only a small number of producers and smaller food hubs near production areas are needed. Given that small and medium producers prefer to travel no more than 50 miles to a food hub, transportation costs from the hub to retail distribution centers can become high if the demand for local blueberries increases. Planning on investment in food hub numbers and capacity should also take into consideration blueberry productivity fluctuations.

Extension programs in every state are involved in local food systems assessment and development, as evidenced by their prominent placement in the state resources directory of the National Agricultural Marketing Resource Center (AgMRC.org). Extension efforts related to local food hub assessment may be funded by USDA-AMS grants, such as the Specialty Crop Block Grant Program (SCBGP), as partnerships with state agricultural departments, or in multi-entity/agency partnerships with programs such as the MarketMaker United States (https://foodmarketmaker.com/). Ex ante studies such as this one could support extension programs by providing analytical tools that help communities and stakeholders evaluate alternative distribution models, infrastructure needs, or cost structures before investments are made. In addition, research on supply chain network design provides extension educators with adaptable, evidence-based insights that can be translated into guidance for producers, cooperatives, and local government in planning.

There are several limitations to this research. First, we assumed homogeneous productivity across all blueberry fields and standardized transportation modes using 4-ton and 8-ton trucks. These assumptions could be refined in future studies by incorporating field-level data on the age of blueberry bushes and associated yields, as well as operational data on the economic efficiency of transportation modes for distributing fresh blueberries within the state. Second, supply and demand seasonality, uncertainty, and risk management were not addressed in this study. Future research should focus on understanding seasonal and spatial demand patterns to better inform producers' decisions about when and whether to harvest fresh blueberries for local markets. Third, this study used the centroids of each metropolitan and micropolitan area as proxies for retail distribution centers. This approach could be improved by including information on which major retailers would participate in distributing locally grown, fresh blueberries in Georgia. Despite these limitations, the research provides valuable insights into methods and information that can support strategic planning for stakeholders and regional planners interested in developing large-scale local food distribution systems.

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