Supplementary Material

Community-informed Decisions for Equitable, Cost-effective, and Inclusive Disaster Resilience Planning (Co-DECIDR): A modeling approach

A: Scenario Analysis through FCM Collective Intelligence Model

The collective intelligence (CI) model created through FLPP (see Figure A1) was used as the basis for running "what-if" scenarios for evaluating the impacts of alternatives on Community Identified Values (CIVs) and other system components. For the scenario analysis, the CI model adjacency matrix was loaded in ***Mental Modeler*** online tool (Gray et al., 2013[1]). For all the analysis, "hyperbolic tangent" squishing function was selected.

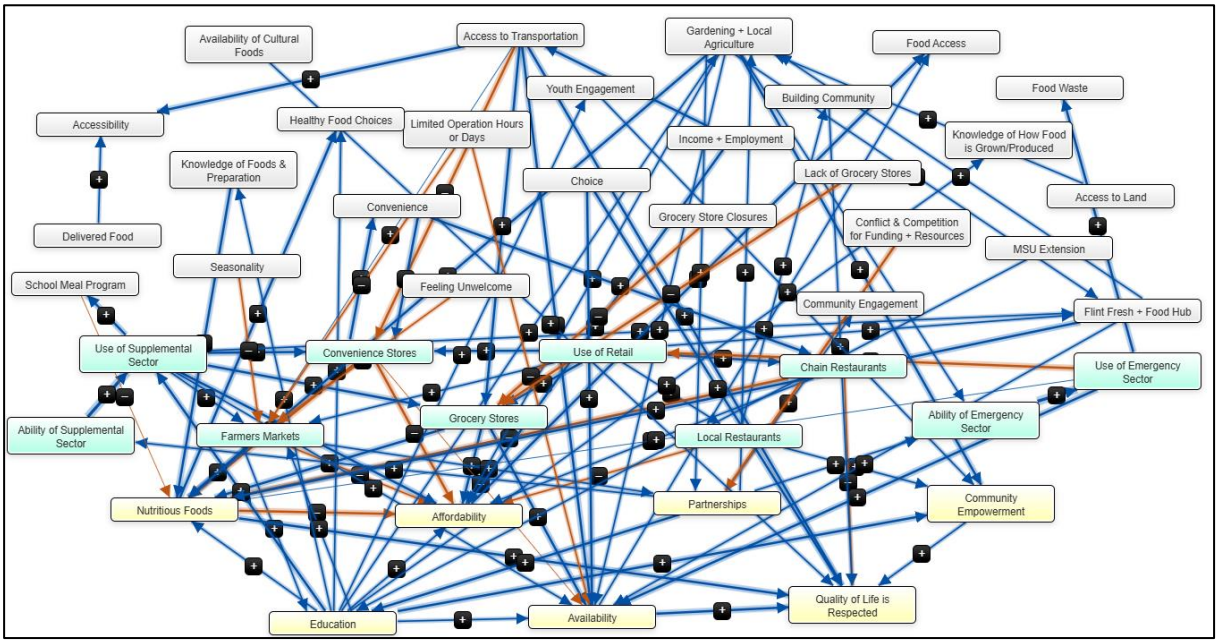

Figure A1: Collective intelligence model generated from 51 FCM interviews with Flint food system experts, adapted from Knox et al., 2023[4].

Modification of CI model for Shocks:

As described in manuscript, we utilized previously CI model (Figure A1) aggregated from individual FCMs to offer a generalized view of the Flint Food System. Although respondents added COVID-19-related elements to their models at the last step of the interviews (Knox et al., 2023[2]), these were excluded from the creation of the collective model, which aimed to reflect the broader food system dynamics rather than a pandemic-specific model. Each respondent prepared two versions of their model: the original (version 1), representing the general food system, and a modified version incorporating COVID-19 impacts (version 2). Participants identified

[1] Gray, S. A., Gray, S., Cox, L. J., & Henly-Shepard, S. (2013, January). Mental modeler: a fuzzy-logic cognitive mapping modeling tool for adaptive environmental management. In *2013 46th Hawaii International Conference on System Sciences* (pp. 965-973). IEEE.

[2] Knox, C. B., Gray, S., Zareei, M., Wentworth, C., Aminpour, P., Wallace, R. V., ... & Brugnone, N. (2023). Modeling complex problems by harnessing the collective intelligence of local experts: New approaches in fuzzy cognitive mapping. *Collective Intelligence*, *2*(4), 26339137231203582.

impacts by adding connections between the COVID-19 component and other food system components. For instance, Figures A2 and A3, display individual FCMs that detail these impacts (their version 2 mental models that were not used in creating the collective intelligence model). We analyzed the frequency of edges linking COVID-19 to other components in the version 2 FCMs, using these connections for model modification and scenario analysis to assess COVID-19's impact on the Flint Food System. While components such as “Grocery Store,” “Chain Restaurants,” and “Education” were mentioned 10 or more times, the inconsistency in the described weights (some positive, some negative) led to their exclusion from the CI model modification to maintain impact direction consistency. Additionally, some edges were not considered due to insufficient mentions. Table A1 summarizes the edges between COVID-19 and CI model components mentioned by participants. Consequently, a modified CI model (Figure A4) was developed by integrating 6 new edges with calculated average weights from participants, incorporating the most agreed-upon effects of COVID-19 into previously created Flint food system CI model. Conversely, the extreme weather impacts were not explicitly modelled due to a lack of direct questions during the FCM interviews; adjustments were made only to the node values of" public transportation" component in CI model to simulate this shock through the FCM assessment.

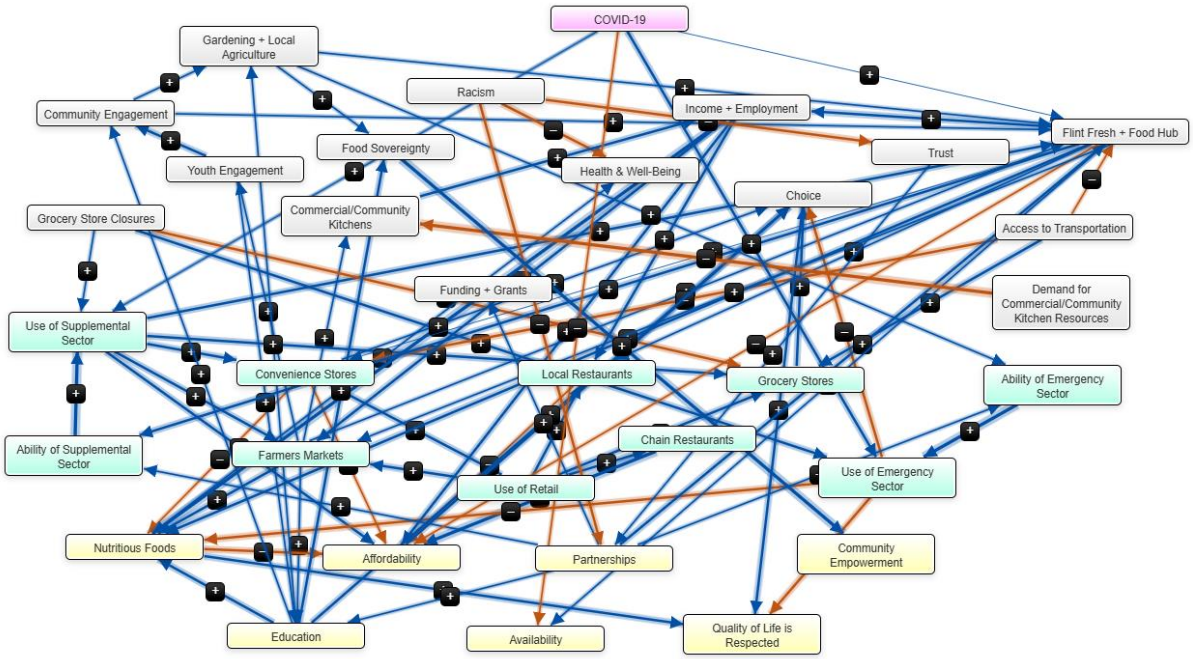

Figure A2: FCM of participants #124 and how they described the impacts of COVID-19 on their FCM.

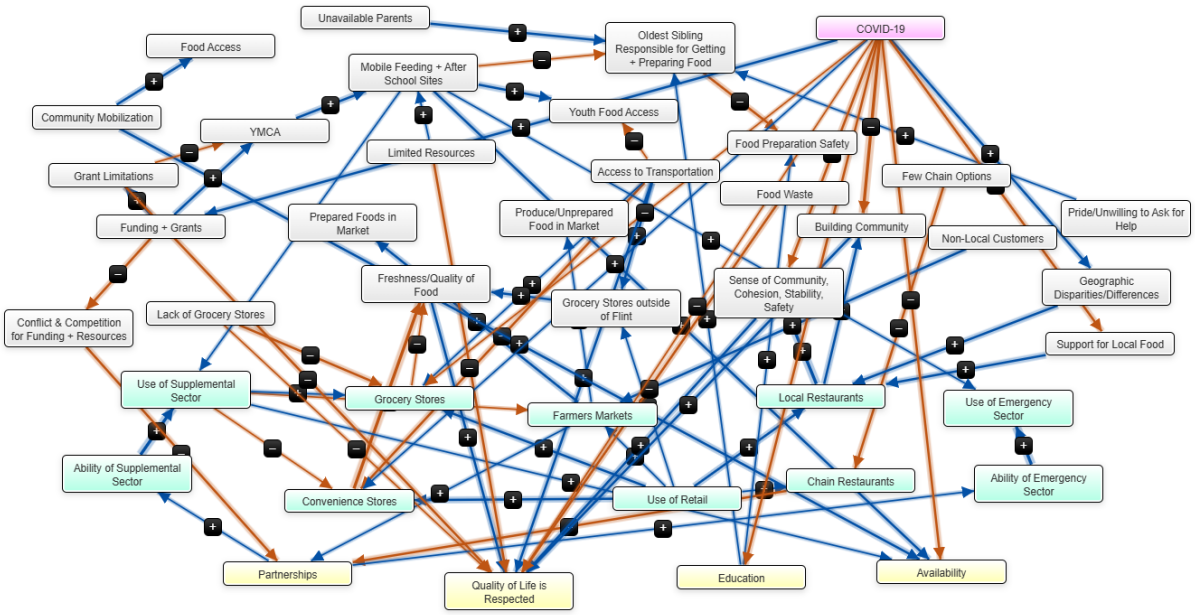

Figure A3: FCM of **participants #147** and how they described the impacts of COVID-19 on their FCM.

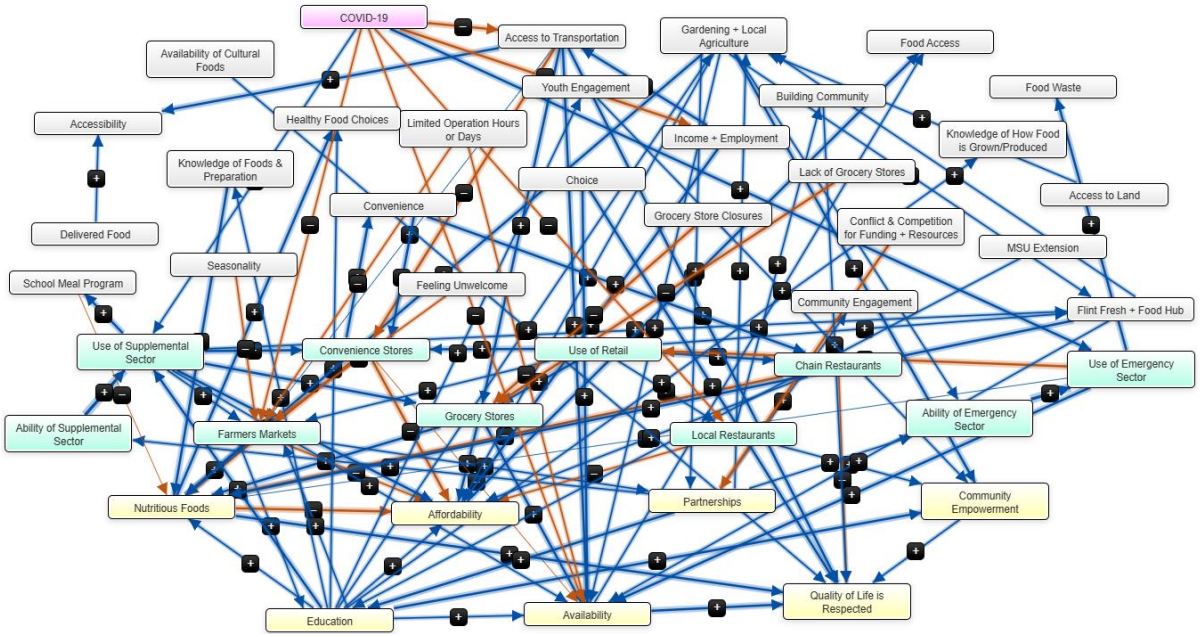

Figure A4: Adding 6 new connections between COVID-19 and components of previously created CI model by Knox et al., 2023[4]. Table A1 represents these new edges and their average weights.

Table A1: Connections mentioned by participants from COVID-19 to CI food system components. Connections with a frequency of 4 or lower are not reported in this table.

Edges mentioned by Participants related to COVID-19		# of participants mentioned	Used/Not Used in the modified CI model
From	To		
COVID-19	Use of Emergency Sector	21	This edge was added to the CI model with a **weight of +0.63**
COVID-19	Local Restaurants	20	This edge was added to the CI model with a **weight of -0.48**
COVID-19	Use of Supplemental Sector	14	This edge was added to the CI model with a **weight of +0.4**
COVID-19	Availability	12	This edge was added to the CI model with a **weight of -0.41**
COVID-19	Farmers Markets	10	This edge was added to the CI model with a **weight of -0.3**
COVID-19	Access to Transportation	10	This edge was added to the CI model with a **weight of -0.54**
COVID-19	Income + Employment	10	This edge was added to the CI model with a **weight of -0.62**
COVID-19	Grocery Stores	15	The edge was not added to the CI model due to inconsistent directionality in the weights described by participants
COVID-19	Chain Restaurants	12	
COVID-19	Education	10	
COVID-19	Partnerships	8	The edge was not added due to insufficient mentions by participants.
COVID-19	Gardening + Local Agriculture	7	
COVID-19	Ability of Emergency Sector	6	
COVID-19	Ability of Supplemental Sector	5	
COVID-19	Accessibility	5	
COVID-19	Nutritious Foods	5	

Alternatives for COVID-19:

To cope with COVID-19, two alternatives were considered: 1) establishing a new open-air farmers market, and 2) opening a food hub with online marketing. Both the "farmers market and "food hub" were one of the system's components within the CI model; their relationships with other system components in the Flint Food System were mentioned during data collection through fuzzy cognitive maps. Consequently, no modification to the CI model was required.

For the analysis evaluating the open-air farmers market, the concepts "Farmers Market," "Seasonality," "Healthy Food Choices," and "Knowledge of How Food Is Grown/Produced" in the CI model were set to one (+1). Figure A5 illustrates the impacts of this alternative on all system components in the Flint Food System.

Similarly, to evaluate the food hub with online marketing, the concepts "Flint Fresh + Food Hub" and "Food Delivery" were set to one (+1). Figure A6 shows the impacts of this alternative on all the system components in the Flint Food System.

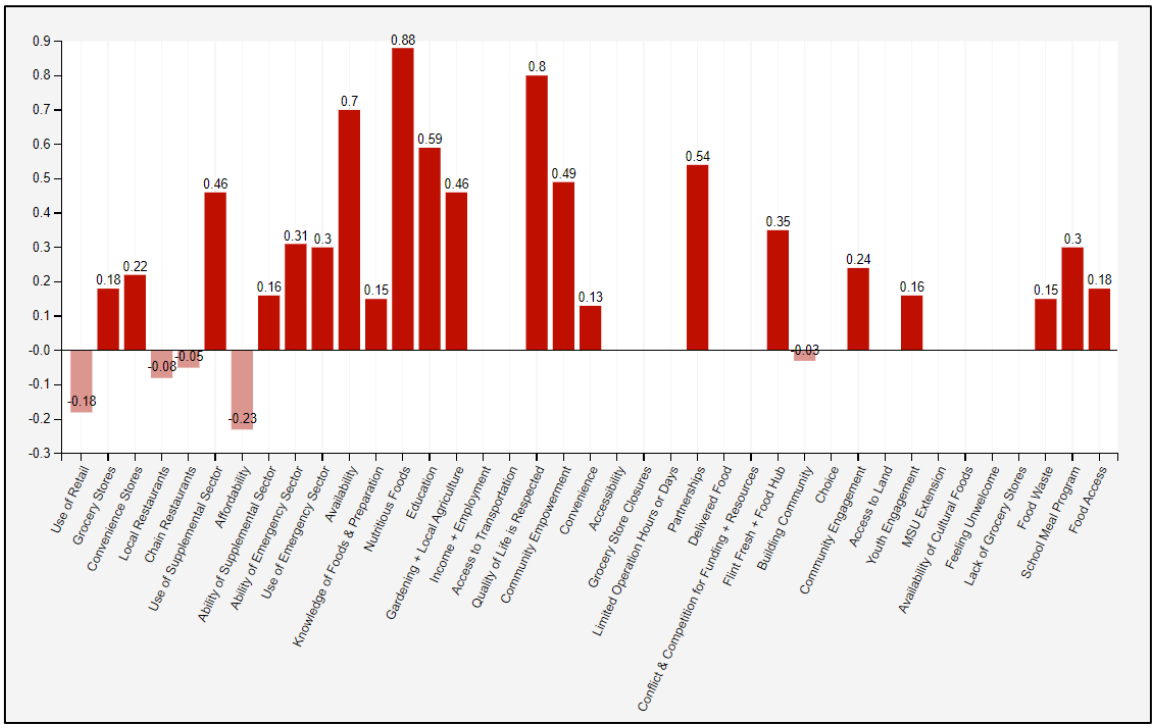

Figure A5: FCM scenario results of increasing "Farmers Market," "Seasonality," "Healthy Food Choices," and "Knowledge of How Food Is Grown/Produced".

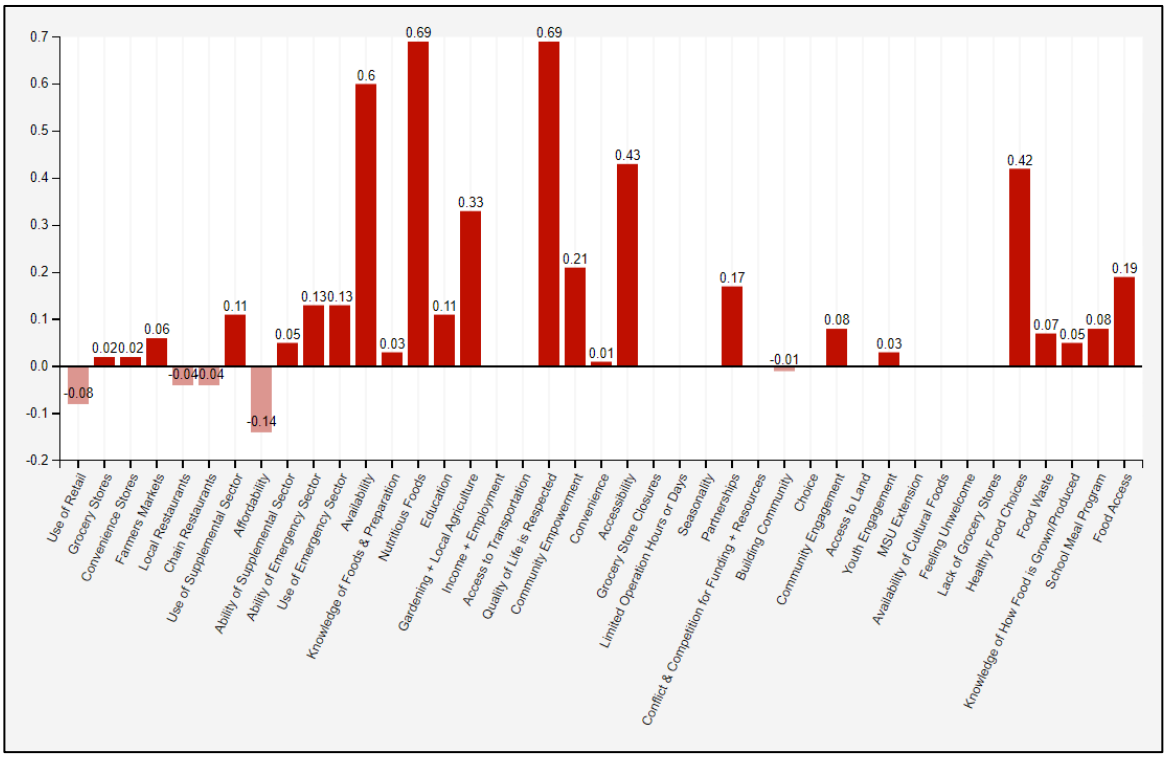

Figure A6: FCM scenario results of increasing "Flint Fresh + Food Hub" and "Food Delivery".

Alternatives for Extreme Weather Events:

To address heat waves and severe precipitation affecting Flint community members' food accessibility, two alternatives were proposed: 1) the construction of 100 new bus shelters and 2) the upgrading of 10 convenience stores to offer healthy, locally sourced fresh products. Unlike the COVID-19 alternatives, where related system components were already included in the CI model, there were no existing concepts for bus shelters or healthy convenience stores. For the bus shelters, we assumed that "Access to Transportation," an existing CI model concept, would improve with the construction of new bus shelters and hence was set to one (+1). Figure A7 demonstrates the impacts of this alternative on all system components in the CI model for the Flint Food System.

While the "convenience store" concept existed in the CI model, it did not capture the dynamics of a "healthy convenience store" as described in the main manuscript section 3.2. Therefore, modifications were made to the convenience store concept and its interactions with other system components within the CI model. Table A2 represents all these changes. Even with conservative estimates for new interactions and strengths, an increase in various concepts were observed by setting the “healthy convenience store” to one (+1). Figure A8 demonstrates the impacts of this alternative on all system components in the CI model for the Flint Food System.

Table A2: Modified CI model connection strengths for healthy convenience store scenario.

Edge:	Original Strength:	New Strength:
Convenience Stores to Nutritious Foods	-0.6	+0.2
Convenience Stores to Availability	-0.12	+0.1
Convenience Stores to Affordability	-0.57	+0.2
Convenience Stores to Availability of Cultural Foods	0	+0.1
Convenience Stores to Building Community	0	+0.1
Convenience Stores to Gardening + Local Agriculture	0	+0.1

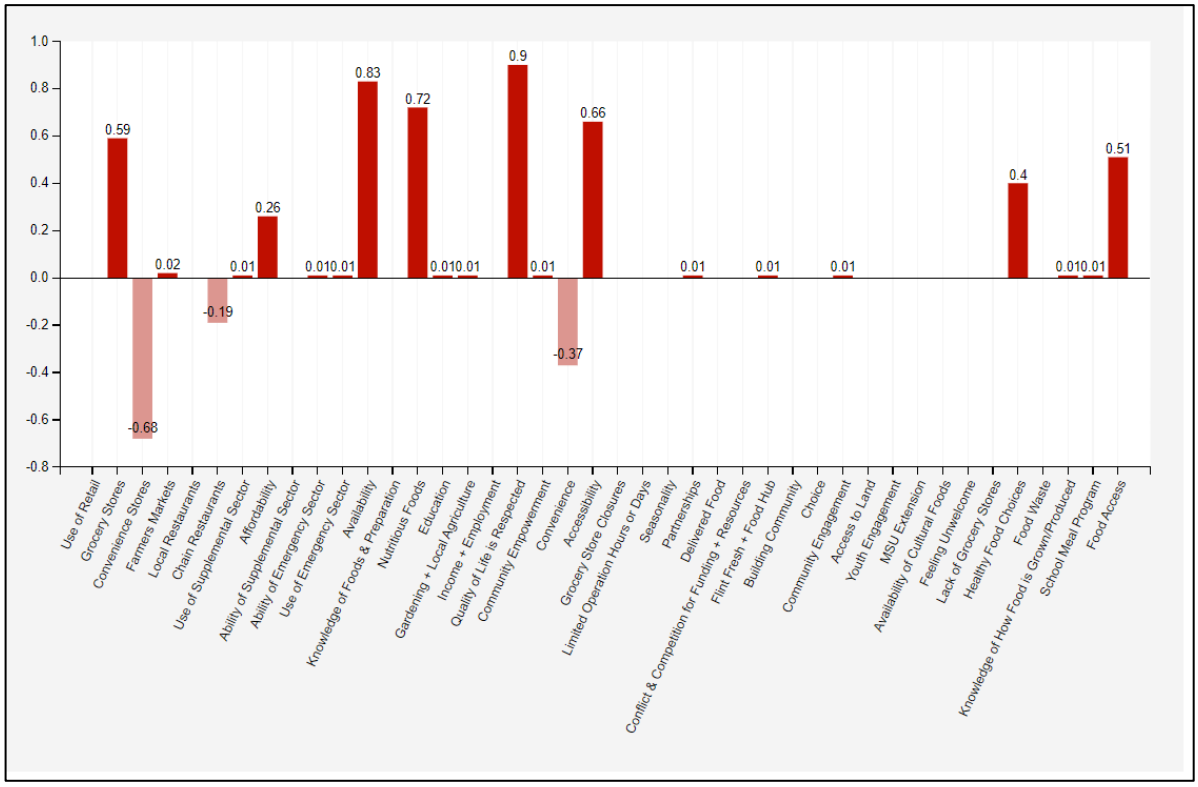

Figure A7: FCM scenario results of increasing “Access to Transportation".

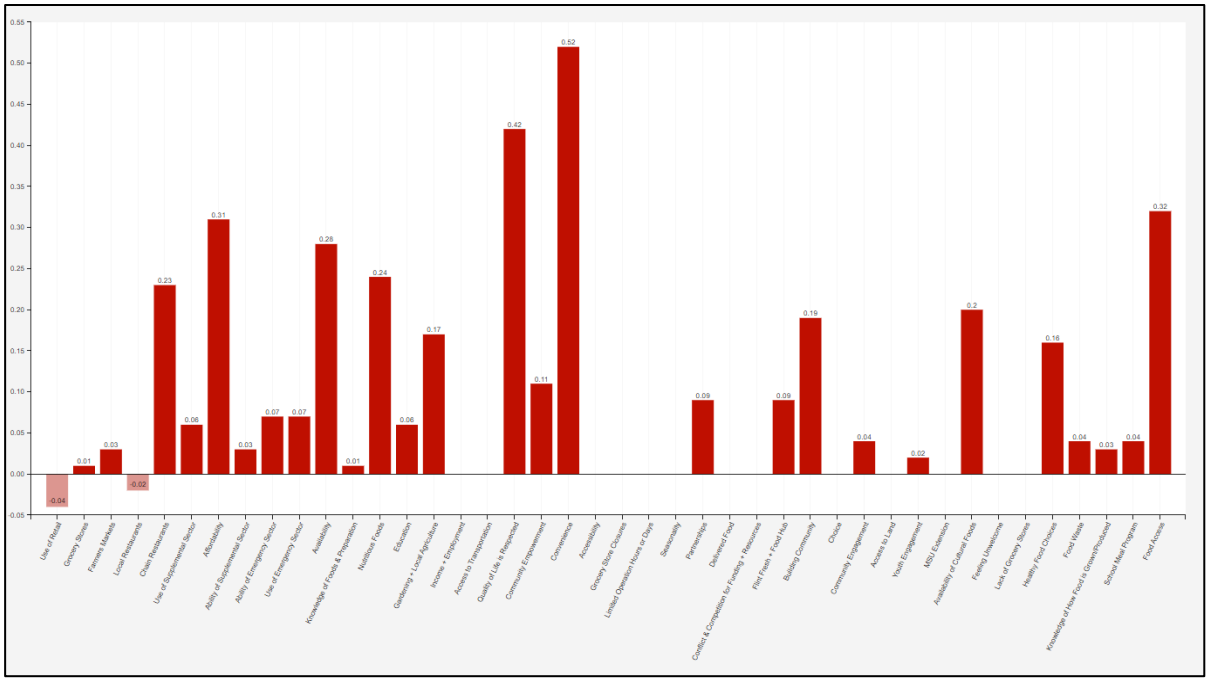

Figure A8: FCM scenario results of modified CI model based on the Table A1.

B: Input Data for the Benefit-Cost Analysis

1: Open-air (Outdoor) Farmers Market:

This alternative proposes the establishment of a new medium-sized open-air (outdoor) farmers market, with a maximum capacity of 35 vendors (MIFMA, 2017[3]). The market, run by the local government, will offer seasonal services to vendors and customers from mid-April to mid-November (7 months). It will operate in a suitable parking lot, allowing vendors to use the space once a week on Saturdays from 8 am to 3 pm. Vendors will be charged a rental fee and are required to set up their own stalls or booths, payment processing equipment, and other marketing materials.

The potential sources of costs, benefits, and externalities have been identified based on available secondary data and preliminary findings from interviews with a limited number of local farmers market directors. Table B1 summarizes these values for the best-case, mean-case, and worst-case scenarios.

Table B1: Summarized costs, benefits, and externalities for the open-air farmers market alternative.

			Value		
	Item	*Classification*	*Best Case*	*Mean Case*	*Worst Case*
Open Air Farmers Market	Rent for the site	Cost	$3,000	$15,000	$24,000
	Initial Supplies and Miscellaneous	Cost	$3,500	$6,000	$9,000
	Market Management and Staffing	Cost	$80,000	$100,000	$125,000
	Licenses and Permits	Cost	$95	$150	$255
	Insurance	Cost	$1,000	$2,000	$3,000
	Utility and Services	Cost	$1,750	$4,200	$7,000
	Marketing and Promotions	Cost	$4,500	$5,400	$6,000
	Revenue from Vendor Fees	Benefit	$78,750	$55,500	$26,250
	Health Benefits	Externality	$50,000	$35,000	$20,000
	Spillover Effect on Nearby Businesses	Externality	$66,570	$57,500	$44,380
	Reduction in Losses of Closed Food Outlets	Externality	$252,000	$210,000	$170,000
	Reduction in Food Insecure People	Externality	$62,500	$50,000	$37,500
	Fatalities Averted	Human Life	10	8	6

1.1: Costs

1.1.1: Rent for the site: If the market is set up in rented parking lots, there might be a rental fee. This cost can vary greatly based on location and size but could range from $100 to $800 per market day (estimated based on the interviews). Regarding the operation time of 7 months per year, it can range from $3,000 to $24,000 per year.

[3] Michigan Farmers Market Association (MIFMA). (2017). Market Manager Compensation Report 2017. Retrieved from https://mifma.org/wp-content/uploads/2020/07/MIFMA-Market-Manager-Compensation-Report-2017.pdf

1.1.2. Initial Supplies and Miscellaneous: Includes costs for items like tables, chairs, tents, and signage for each market day. This might range from $3500 to $9000. [Every 10 years needs to be renewed] (estimated based on the interviews).

1.1.3. Market Management and Staffing: Staff costs for setting up, managing, and dismantling the market, along with administrative tasks. This could be around $80,000 to $125,000 per year, depending on the number of staff and hours worked (MIFMA, 2017[5]).

1.1.4. Licenses and Permits: Costs for necessary permits and licenses for outdoor farmers market can vary but might be around $95 to $255 (State of Michigan, 2023[4])

1.1.5. Insurance: Liability insurance is essential for protecting against accidents or damage. This could cost approximately $1000 to $2000 per year (estimated based on the interviews).

1.1.6. Utility and Services: This includes costs for electricity, water, and waste management. For a market operating once a week, this might range from $50 to $200 per market day, depending on the services needed and the length of the market (estimated based on the interviews).

1.1.7. Marketing and Promotions: This is vital for attracting both vendors and customers. Costs for digital and print advertising, social media promotion, and signage could range from $150 to $200 per market day (estimated based on the interviews).

1:2: Benefits

1.2.1: Revenue from Vendor Fees: Vendors might pay a fee to participate in the market, which can range from $25 to $75 per day or more, depending on the market size and location. Based on the assumption of 35 vendors during the operation of outdoor farmers market, it can provide $26,250 to $78,750 per year (MIFMA, 2017[5]; NASS, 2017[5]).

1.3: Externalities:

1.3.1: Health Benefits: Shopping at farmers markets is linked to higher fruit and vegetable intake, suggesting that these markets are an effective strategy for enhancing overall consumption of produce in the population (Pitts et al., 2014[6]). Increased fruit and vegetable consumption can lead to better community health outcomes. Quantifying this in dollar terms is complex, but reduced healthcare costs due to improved diets could average from $100 to $250 per person annually. It has been assumed $20,000 to $50,000 for 200 customers per year.

1.3.2: Spillover Effect on Nearby Businesses: Farmers' markets not only attract customers to their stalls but also encourage these visitors to spend money at other local businesses (Morckel & Colasanti et al., 2018[7]; Sadler et al., 2013[8]). Regarding the Morckel & Colasanti (2018)[9] study, people who visit the Flint indoor farmers' market typically spend an extra $6.34 at nearby shops and restaurants during their market visit. Considering this, our analysis assumes that 20% of all visitors to the market throughout the year, totaling 45,000 people, will spend this additional amount in the surrounding area. By multiplying 20% of the 35,000 to 52500 annual visitors and by the average extra spending of $6.34, we estimate that the farmers' market could generate an additional $44,380 to $66,570 per year for local businesses.

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[4] State of Michigan. (2023). Farmers market FAQ. Retrieved from: https://www.michigan.gov/mdard/food-dairy/farmersmarket/farmers-market-faq

[5] National Agricultural Statistics Services (NASS). (2020) National Farmers Market Mangers Report. Retrieved from: https://www.nass.usda.gov/Publications/Todays_Reports/reports/nfar0820.pdf

[6] Pitts, S. B. J., Gustafson, A., Wu, Q., Mayo, M. L., Ward, R. K., McGuirt, J. T., ... & Ammerman, A. S. (2014). Farmers' market use is associated with fruit and vegetable consumption in diverse southern rural communities. *Nutrition journal*, *13*, 1-11.

[7] Morckel, V., & Colasanti, K. (2018). Can farmers' markets in shrinking cities contribute to economic development? A case study from Flint, Michigan. *Sustainability*, *10*(6), 1714.

[8] Sadler, R. C., Clark, M. A., & Gilliland, J. A. (2013). An economic impact comparative analysis of farmers' markets in Michigan and Ontario. *Journal of Agriculture, Food Systems, and Community Development*, *3*(3), 61.

1.3.3: Reduction in Losses of Closed Food Outlets: By selling directly to consumers, farmers can retain a higher percentage of the profit (Hughes et al., 2022[9], Park et al., 2014[10]). This might increase farmer incomes by around 15-30%, potentially adding up to an extra $5,000-$10,000 per farmer annually. By assuming 35 vendors could continue their business during the COVID-19 and making $160 -$240 per market day, it could prevent a loss of $170,000 to $252,000.

1.3.4. Fatalities Averted: During the COVID-19 pandemic, Flint witnessed the loss of approximately 400 lives. Assuming a 1.5% to 2.5% reduction in the number of fatalities due to the lower transmission rate of the virus in open-air spaces, this would imply that engaging more in outdoor activities or having more facilities that operate outdoors could have potentially saved between 6 to 10 individuals.

2: Food Hub with Delivery Services:

The second alternative represents the establishment of a new medium-large food hub with a 15,000 square foot space (report 2021 food hub[11]). This food hub employs 10 full-time and 5 part-time staff members. Designed to operate without a traditional storefront, this hub will instead focus on an online marketplace for both fresh and processed food items, including a variety of fruits, vegetables, meat, dairy, and bread, along with specialty products like fruit jams and dried goods. The platform will deliver the products to the individual consumers, while also providing a wholesale distribution channel to serve restaurants, schools, and other organizations. By combining the convenience of online shopping with a comprehensive product range, the food hub aims to support local agriculture, enhance food accessibility, and meet the needs of diverse customers.

The potential estimations of costs, benefits, and externalities have been identified based on available reports and preliminary findings from interviews with a limited number of local fresh market directors. Table B2 summarizes these values for the best-case, mean-case, and worst-case scenarios.

2.1: Costs

2.1.1: Purchasing Property: Initial investment for purchasing a property of 15,000 square foot for the food hub has been estimated between $750,000 and $1,500,000 based on the average price for industrial spaces in Michigan.

2.1.2: Equipment and Initial Setup: Depending on the food hub's operational needs for processing, packaging, and refrigerating the products, the estimated investment for equipment and initial setup for a food hub with 15,000 square foot range between $250,000 and $500,000 (estimated based on the interviews).

[9] Hughes, M., Pressman, A., Oberholtzer, L., Dimitri, C., & Welsh, R. (2022). Selling to Local and Regional Markets: Barriers and Opportunities for Beginning Farmers. *National Center for Appropriate Technology. IP595*.

[10] Park, T., Mishra, A. K., & Wozniak, S. J. (2014). Do farm operators benefit from direct to consumer marketing strategies?. *Agricultural Economics*, *45*(2), 213-224.

[11] Center for regional food systems (CRFS). (2023) 2021 National Food Hub Survey Report. Retrieved from: https://www.canr.msu.edu/foodsystems/uploads/MSU-007-CRFS-2021-National-Food-Hub-Survey-Report-Final1.pdf

Table B2: Summarized costs, benefits, and externalities for the food hub with delivery services alternative.

			Value		
	Item	*Classification*	*Best Case*	*Mean Case*	*Worst Case*
Food Hub with Delivery Services	Purchasing Property	Cost	$750,000	$1,100,000	$1,500,000
	Equipment and Initial Setup	Cost	$250,000	$350,000	$500,000
	Staffing	Cost	$210,000	$300,000	$510,000
	Utility and Services 2	Cost	$24,000	$33,000	$60,000
	Raw Materials	Cost	$220,000	$450,000	$660,000
	Packaging	Cost	$18,000	$24,000	$36,000
	Marketing and Promotions 2	Cost	$12,000	$22,000	$36,000
	Licenses and Permits 2	Cost	$2,000	$4,000	$5,000
	Insurance 2	Cost	$3,500	$4,200	$5,500
	Revenue from Online Sales	Benefit	$420,000	$360,000	$270,000
	Revenue from Wholesale	Benefit	$576,000	$480,000	$168,000
	Non-Sale Revenue	Benefit	$100,000	$75,000	$30,000
	Job Creation	Externality	$510,000	$300,000	$210,000
	Enhanced Income of Small Farm Businesses	Externality	$700,000	$500,000	$300,000
	Waste Management	Externality	$35,000	$25,000	$15,000
	Reduced losses of Increased prices	Externality	$750,000	$693,530	$500,000
	Fatalities Averted	Human Life	12	10	8

2.1.3: Staffing: Assuming 10 full-time job and 5 part-time job, the yearly payroll can be estimated between $635,000 and $950,000 (CRFS, 2023[13])

2.1.4: Utility and Services: Monthly utilities and service expenses might range from $2,000 to $5,000.

2.1.5: Raw Materials: Costs for sourcing raw materials such as fruits, vegetables, meats, eggs, and bread are projected to be $10,000 to $30,000 per month (CRFS, 2023[13]; CRFS, 2020[12]).

2.1.6: Packaging: Costs for packaging materials, including boxes, jars, and other necessary packaging for processed food items, are estimated to range from $3,000 to $6,000 monthly (estimated based on the interviews).

2.1.7: Marketing and Promotions: To effectively market the online marketplace and attract both individual and wholesale customers, monthly expenses for digital marketing and website operations are anticipated to be $1,000 to $3,000 (estimated based on the interviews).

[12] Center for regional food systems (CRFS). (2020) 2019 National Food Hub Survey Report. Retrieved from: https://www.canr.msu.edu/foodsystems/uploads/files/Findings-of-the-2019-National-Food-Hub-Survey-Report.pdf

2.1.8. Licenses and Permits: Costs for necessary permits and licenses for food hub that offers delivery services and include food processing can vary from $2,000 to $5,000 (State of Michigan, 2023[6])

2.1.9. Insurance: It has been estimated that the food hub would need to budget $3,500 to $5,500 annually for liability and property insurance to protect against operational risks (estimated based on the interviews).

2:2: Benefits

2.2.1: Revenue from Online Sales: Based on an average order of $40 and receiving between 250 to 400 orders per month, the annual sales can range from $120,000 to $192,000 (CRFS, 2023[13]).

2.2.2: Revenue from Wholesale: For wholesale, with the food hub having between 7 to 12 clients making average purchases of $2,000 to $4,000 per month, the annual revenue can range from $168,000 to $576,000 (CRFS, 2023[13]).

2.2.3: Non-Sale Revenue: For this alternative, the food hub might make between $30,000 and $100,000 a year from non-sale revenues. This extra money could come from diverse sources, such as federal and state government grants, contributions from individuals, and funds from private foundations. This reflects findings from a 2021 report on food hubs, which indicated that nearly two-thirds of such hubs benefitted from similar non-sales income streams (CRFS 2023[13], CRFS, 2020[14]).

2:3: Externalities

2.3.1: Job Creation: This food hub is able to create 10 full-time and 5 part-time job opportunities for the local community. The salaries for employees can range from $36,210 to $47,500 and for the managers from $47,843 to $64,827 (CRFS, 2023[13]).

2.3.2: Enhanced income of small farm businesses: Food hubs usually source their products from local/regional small farm businesses that cannot compete with larger producers due to various constraints, such as limited access to markets or insufficient volume. The food hub can facilitate the aggregation, distribution, and marketing of food products, thereby providing small farm businesses with a vital link to larger markets. Assuming the food hub collaborates with 40 local/regional small-farm businesses per year, a meaningful estimation for the purchasing amount from them could be in the range of $300,000 to $700,000 per year (estimated based on the interviews).

2.3.3: Waste Management: Annually, a significant quantity of fresh products, such as fruits and vegetables, is wasted due to the lengthy supply chains at the national level (Reference). Food hubs that engage in close collaboration with local or regional producers can benefit from shorter supply chains, leading to a reduction in the waste rate of fresh produce. By achieving a 5% reduction (Assumed) in waste from fresh produce and assuming annual purchases from producers amounting to between $300,000 and $700,000, this efficiency could translate into savings ranging from $15,000 to $35,000.

2.3.4. Fatalities Averted: During the COVID-19 pandemic, Flint witnessed the loss of approximately 400 lives. Assuming a 2% to 3% reduction in the number of fatalities due to the lower transmission rate of the virus as people could benefit from online marketing, this would imply that leveraging online marketing strategies to promote social distancing and reduce physical interactions could have potentially saved between 8 to 12 individuals.

3: Bus Shelters

Table B3: Summarized costs, benefits, and externalities for the bus shelter alternative.

			Value		
	Item	*Classification*	*Best Case*	*Mean Case*	*Worst Case*
Bus Shelters	Construction	Cost	$1,000,000		
	Maintenance	Cost	$100,000		
	Public Transport Ridership	Benefit	$448	$265	$130
	HRI Cases	Externality	$6,137	$1,614	$306
	Food Waste	Externality	$1,036	$389	$130
	Vehicle Accidents	Externality	$16,903	$10,866	$6,037
	Fatalities Averted	Human Life	0.01975	0.007	0.00143

3.1: Costs

3.1.1: Construction: Costs of bus shelters are highly variable, with basic models ranging from $10,000-$12,000 (Wesoff, 2011[13]) and higher-end shelters with features like climate control costing $40,000 (Mohl, 2019[14]). For the purposes of this analysis, we will assume a lower cost of $10,000 for a shelter with benches, a roof, and walls ($10,000/shelters * 100 shelters = $1,000,000 for Lifespan: 30 years)

3.1.2: Maintenance: Yearly maintenance: 20 hours of maintenance per year (Mohl, 2019[16]) * hourly wage: $25/hour (Assumption) * 100 shelters + maintenance materials: $500 (Assumption) * 100 shelters = $100,000/year

3.2: Benefits

3.2.1: Increase in Ridership: During heatwaves: Increase in ridership for stops with shelters, during high temperatures: 0.275% (Miao et al., 2019[15]) * Daily Ridership: 5270 (MTA, 2022[16]) * Ridership that benefits from shelters: 20%-40% (Assumption) * Local Fare Price: $1.75 (MTA, 2022[18]) * Duration of heatwave: 3 days = $15.22-$30.43 (or ~9-17 riders) per heatwave. Lost Ridership in Heatwave: $99 * Ridership that benefits from shelters: 20%-40% (Assumption) = $19.80-$39.60 (or ~11-22 riders) per heatwave**.** During rain events: Increase in ridership for stops with shelters, during rain: 0.107% (Miao et al., 2019[17]) * Daily Ridership: 5270 (MTA, 2022[18]) * Ridership that benefits from shelters: 20%-40% (Assumption) * Local Fare Price: $1.75 (MTA, 2022[18]) = $1.97-$3.95 (or ~1-3 riders) per storm**.** Lost Ridership in Rain: $50 (see 2.1.2) * Ridership that benefits from shelters: 20%-40% (Assumption) = $10-$20 (or ~6-12 riders) per storm.

3.3: Externalities

3.3.1: Percentage Reductions in HRI cases and food loss/waste: Costs of HRI cases: $15,321-$51,141, mean: $26,895 * 1%-3% = $153-$1,534/heatwave**.** Mortality from HRI: 0.057-0.1587 * 1%-3% = 0.00057-0.004761/heatwave**.** Costs of food loss/waste: $12,953 * 0.5%-2% = $65-$259/heatwave.

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[13] Wesoff, E. (2011). Solar Bus Shelters From GoGreenSolar. https://www.greentechmedia.com/articles/read/solar-bus-shelters-from-gogreensolar#:~:text=A%20traditional%20bus%20stop%20costs,traditional%20bus%20shelter%20without%20solar .

[14] Mohl, B. (2019). T notes: Bus shelter maintenance pricey. https://commonwealthmagazine.org/transportation/t-notes-bus-shelter-maintenance-pricey/

[15] Miao, Q., Welch, E. W., & Sriraj, P. S. (2019). Extreme weather, public transport ridership and moderating effect of bus stop shelters. Journal of Transport Geography, 74, 125-133. https://doi.org/https://doi.org/10.1016/j.jtrangeo.2018.11.007

[16] MTA. (2022). Financial Report with Supplemental Information. In.

3.3.2: Avoided Crashes: Bus travel can be 40 times safer than auto travel (SWRPC, 2001[17]) and using the assumption that the ridership increases from shelters replaced a car trip, there is a marginal decrease in the number of car accidents. Ridership increase: ~7-15. Decrease in the number of car accidents: 0.091%-0.182%. Cost of Avoided Crashes: $1,231-$2,647/storm. Avoided Fatalities: 0.0000594-0.000128/storm.

4: Healthy Convenience Stores:

This alternative proposes transforming 10 existing convenience stores in different neighborhoods with limited access to fresh markets into "healthy convenience stores". This initiative is designed to enhance infrastructure and facilities within these stores to offer a wide range of fresh local products, including fruits, vegetables, meat, and dairy ensuring higher diversity of choice and affordability. By collaborating with local producers, these health convenience stores will provide consumers--especially the ones without personal vehicles--easy access to healthy food options in their neighborhood, promoting better dietary habits and reducing food deserts. Moreover, shorter distance for purchasing groceries can enhance their accessibility during extreme weather events.

Table B4: Summarized costs, benefits, and externalities for the healthy convenience store alternative.

			Value		
	Item	*Classification*	*Best Case*	*Mean Case*	*Worst Case*
Healthy Convenience Store	Infrastructure Upgrades	Cost	$500,000	$750,000	$1,000,000
	Training and Development	Cost	$10,000	$15,000	$20,000
	Inventory and Sourcing	Cost	$250,000	$350,000	$450,000
	Marketing and Community Engagement	Cost	$24,000	$33,000	$60,000
	Licensing and Compliance	Cost	$20,000	$35,000	$50,000
	Increased Sales	Benefit	$400,000	$300,000	$200,000
	Strengthened Local Economy	Externality	$400,000	$300,000	$200,000
	Health and Nutrition	Externality	$250,000	$175,000	$100,000
	Saving Energy	Externality	$4,800	$3,600	$2,400
	HRI Cases	Externality	$32,272	$26,894	$21,516
	Fatalities Averted	Human Life	0.068	0.056	0.044

4.1: Costs:

4.1.1: Infrastructure Upgrades: The initial investment for upgrading infrastructure (refrigeration, shelving, display units) is estimated between $50,000 and $100,000 per store, totaling $500,000 to $1,000,000 for all 10 stores (based on the available online prices).

4.1.2: Training and Development: Costs for training staff in handling and marketing fresh products might range from $10,000 to $20,000 (Assumption).

[17] SWRPC. (2001). CityExpress Cost/Benefit Analysis.

4.1.3: Inventory and Sourcing: Average costs for sourcing a diverse range of products from the 40 local producers are projected to be $20,000 to $40,000 per store (Qin et al., 2014[18]).

4.1.4: Marketing and Community Engagement: Expenses to market the new offerings and engage the community are anticipated to be $5,000 to $10,000 per year (Assumption).

4.1.5: Licensing and Compliance: Updating licenses and ensuring compliance with food safety standards could require $2,000 to $5,000 per store, or $20,000 to $50,000 in total (Assumption).

4.2: Benefits

4.2.1: Increased Sales: By offering a wider range of fresh and healthy options, sales per store could increase, potentially adding $30,000 to $50,000 in annual revenue per store. For all 10 healthy convenience stores can range from $300,000 to $500,000 per year (Memphis MPO, 2014[19]).

4.3: Externalities

4.3.1: Strengthened Local Economy: Collaborating with 40 local producers on average can inject approximately $300,000 to $700,000 annually into the local agricultural economy (Miller & McCole, 2014[20]).

4.3.2: Health and Nutrition: Enhanced access to local fresh food can improve community health outcomes, potentially reducing healthcare costs in the neighborhood. Quantifying this in dollar terms is complex, but reduced healthcare costs due to improved diets could average $100-$250 per person annually. (Assumed For 1000 customers).

4.3.3. Saving Energy: By enhancing the availability of diverse fresh local products in neighborhoods, this alternative has the potential to significantly reduce travel distances for customers. Assuming it can shorten the travel for 5,000 customers per year from an average of 5-10 miles to 1-2 miles, and considering an average fuel economy of 25 miles per gallon with the price of gas at $3.50 per gallon, it can save $4200 per year.

4.3.4: Reduction in HRI: By reducing the travel distance for customers, people need to spend less time in extreme heat weather and it can considerably reduce the heat-related illnesses (HRI) by 20%-30% (Centers for Disease Control and Prevention, 2023 [21]). Costs of HRI cases: $15,321-$51,141, mean: $26,895 * 30%-40% = $5379-$8,068/heatwave**.** Mortality from HRI: 0.057-0.1587* 30%-40% = 0.011-0.017/heatwave.

[18] Qin, Y., Wang, J., & Wei, C. (2014). Joint pricing and inventory control for fresh produce and foods with quality and physical quantity deteriorating simultaneously. *International Journal of Production Economics*, *152*, 42-48.

[19] Memphis MPO. (2014). YMCA Healthy Convenience Store Plan. Retrieved from: https://memphismpo.org/sites/default/files/documents/resources/projects/greenprint/ymca-healthy-convenience-store-plan.pdf

[20] Miller, C. L., & McCole, D. (2014). Understanding collaboration among farmers and farmers' market managers in southeast Michigan (USA). *Journal of Agriculture, Food Systems, and Community Development*, *4*(4), 71-95.

[21] Centers for Disease Control and Prevention. (2023). CDC Provides Tips for Preventing Heat-Related Illness. Retrieved from : https://www.445aw.afrc.af.mil/News/Article-Display/Article/3458944/cdc-provides-tips-for-preventing-heat-related-illness/#:~:text=The%20Centers%20for%20Disease%20Control%20and%20Prevention,you%20are%20*%20Replace%20salt%20and%20minerals

C: Sensitivity Analysis of Discount Rate and Planning Horizon on Final Scores and Ranking

As outlined in Section 5.5.1, we performed a sensitivity analysis to examine the effects of variations in the Discount Rate (DR) and Planning Horizon (PH) on the final scores and rankings of the candidate alternatives. This appendix investigates the influence of these parameters across worst-case, mean-case, and best-case scenarios in a more detailed manner.

Worst-Case Scenrio:

Figure C1 illustrates the heatmaps for the final scores of the four candidate alternatives under various DR and PH within the worst-case scenario. A clear trend emerges from the data: extending the Planning Horizon generally improves the final scores of all alternatives. Conversely, the Discount Rate exerts a less pronounced effect on the final scores. Specifically, the Open-air Farmers Market (a) and the Bus Shelter (c) show negligible sensitivity to changes in the Discount Rate. In contrast, the Food Hub with Online Marketing (b) and the Healthy Convenience Store (d) exhibit a mild sensitivity, where a lower Discount Rate correlates with slightly higher final scores.

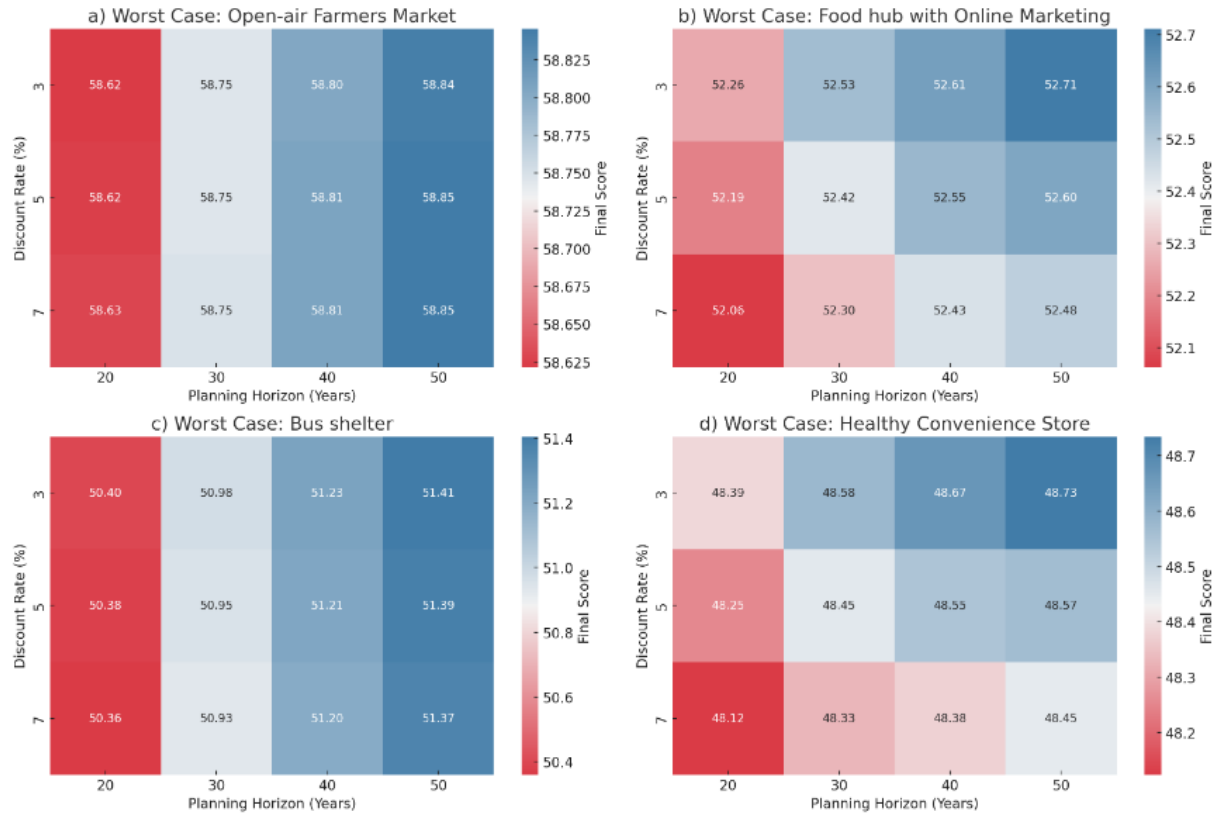

Figure C1: Heatmap for the final scores of each alternative candidate regarding different discount rates and planning horizons for the worst-case scenario.

To assess the impact of variations in DR and PH on the ranking of alternatives, box plots were utilized to visualize the range of final scores. As depicted in Figure C2, the distinct and non-overlapping box plots for each alternative reinforce the stability of their rankings. This indicates that the variations in DR and PH do not influence the relative positioning of these alternatives.

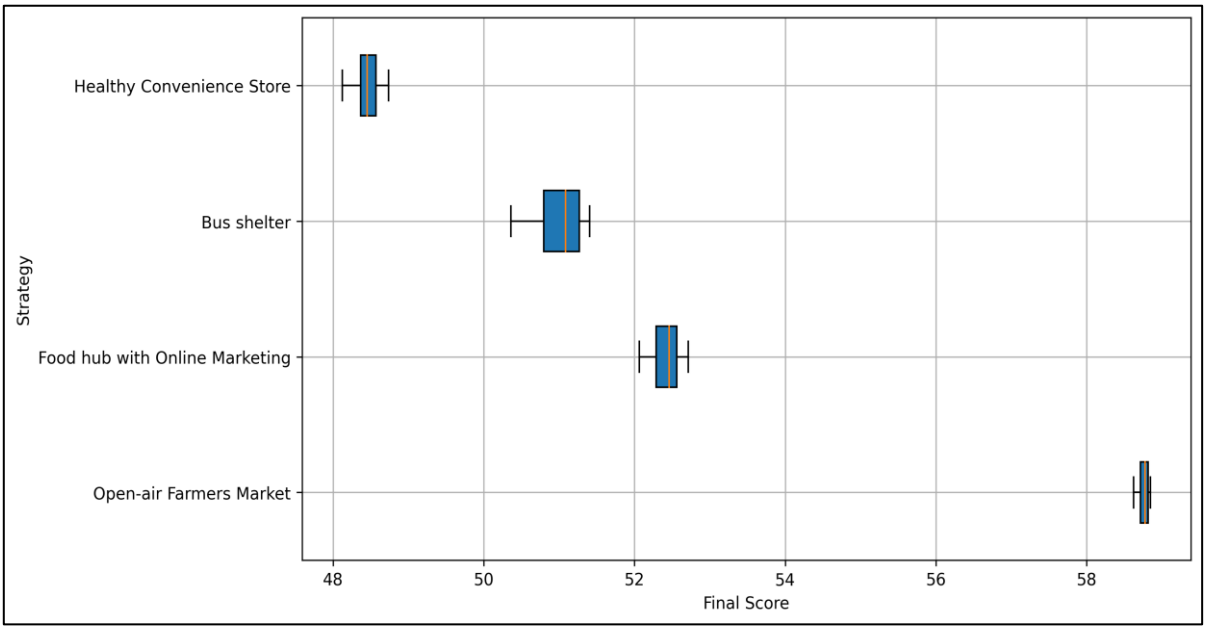

Figure C2: Final score ranges for each alternative based on the variation on DR and HP for the worst-case scenario.

Mean-Case Scenrio:

Figure C3 showcases the heatmaps of final scores for the four alternatives in the context of various DR and PH as part of the mean-case scenario analysis. In contrast to the patterns observed in the worst-case scenario, the data from the mean-case scenario does not reveal a uniform trend. Specifically, for the Open-air Farmers Market (a), the Food Hub with Online Marketing (b), and the Healthy Convenience Store (d), an extended PH corresponds with a decline in final scores. Conversely, for the Bus Shelter (c), an increase in PH continues to result in improved final scores. This divergence in trends could potentially be attributed to the Benefit-Cost Ratio (BCR) for alternatives a, b, and c transitioning from below one to above one, signifying a shift to a more favorable outcome. However, for alternative d, the BCR remained below one. The impact of DR on the final scores was comparatively minor. A varied response was noted where for the Open-air Farmers Market (a), a higher DR was associated with higher final scores, yet for the Food Hub with Online Marketing (b), Bus Shelter (c), and Healthy Convenience Store (d), an increased DR correlated with decreased scores.

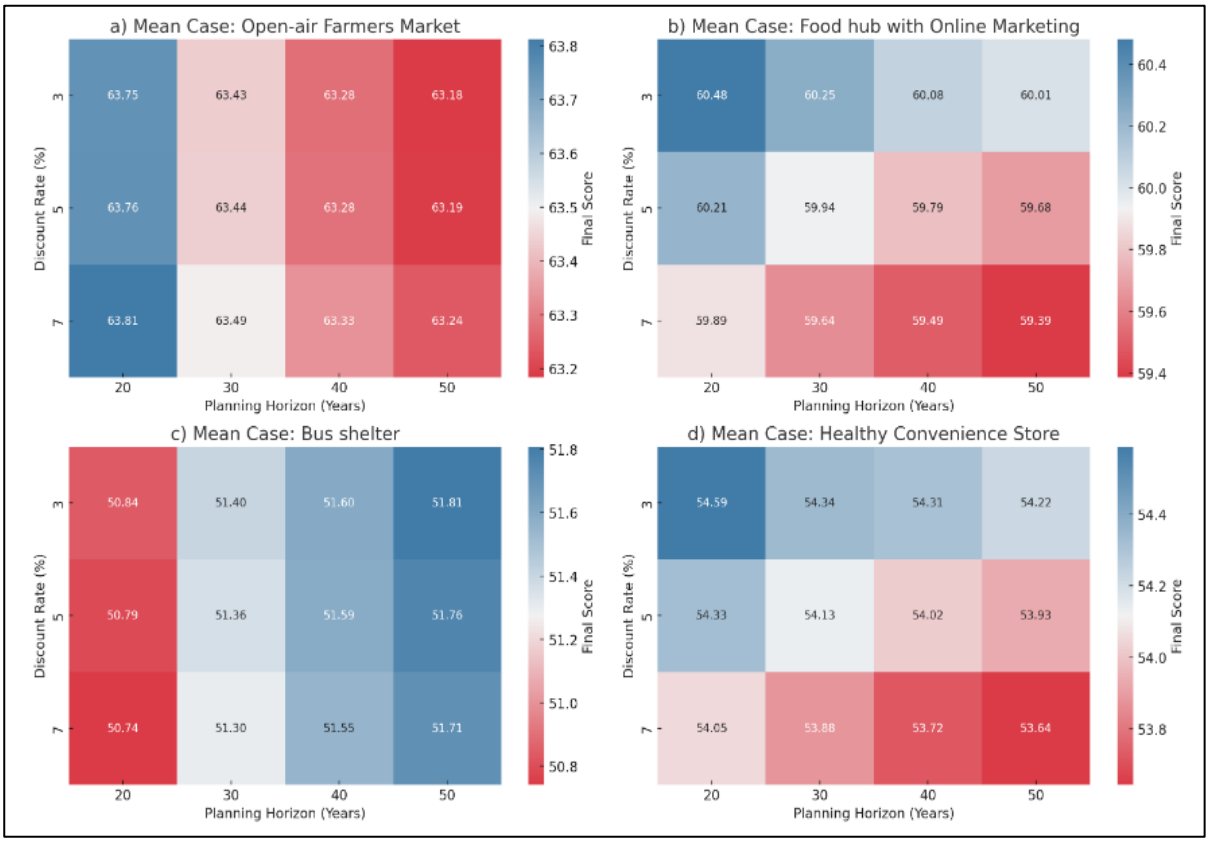

Figure C3: Heatmap for the final scores of each alternative candidate regarding different discount rates and planning horizons for the mean-case scenario.

To assess the impact of variations in DR and PH on the ranking of alternatives, Figure C4 represents the distinct and non-overlapping box plots for each alternative in the mean case scenario. This suggests that the variations in DR and PH do not influence the relative positioning of these alternatives in the mean-case scenario, similar to the worst-case scenario.

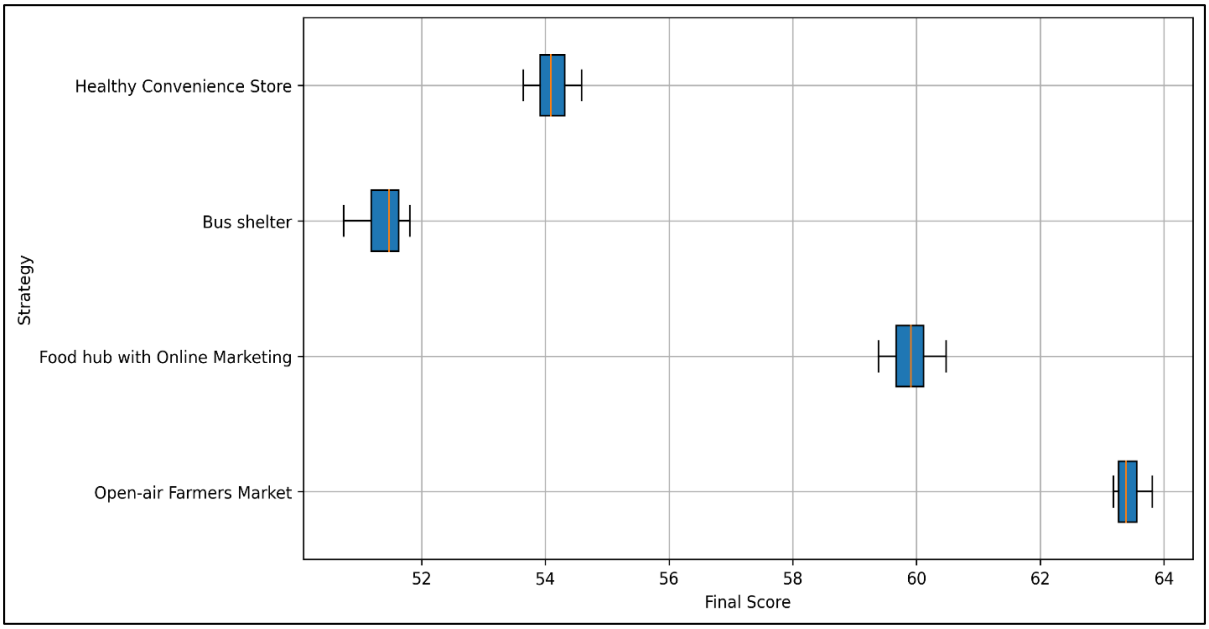

Figure C4: Final score ranges for each alternative based on the variation on DR and HP for the mean-case scenario.

Mean-Case Scenrio:

Figure C5 showcases the heatmaps of final scores for the four alternatives in the context of various DR and PH as part of the **best-case scenario analysis**. Similar to the trends for the mean-case scenario, for the Open-air Farmers Market (a), the Food Hub with Online Marketing (b), and the Healthy Convenience Store (d), an extended PH corresponds with a decline in final scores. Conversely, for the Bus Shelter (c), an increase in PH continues to result in improved final scores—as it has the BCR below 1 even for the best-case scenario. The impact of DR on the final scores was inconsiderable again. A varied response was noted where for the Open-air Farmers Market (a), a higher DR was associated with higher final scores, yet for the Food Hub with Online Marketing (b), Bus Shelter (c), and Healthy Convenience Store (d), an increased DR correlated with decreased scores.

Figure C6 demonstrates the distinct and non-overlapping box plots for each alternative in the best-case scenario. This suggests that the variations in DR and PH do not influence the relative positioning of these alternatives in the best-case scenario, same as the mean-case and worst-case scenarios. It concludes that DR and HP have not impacted the ranking of the alternatives.

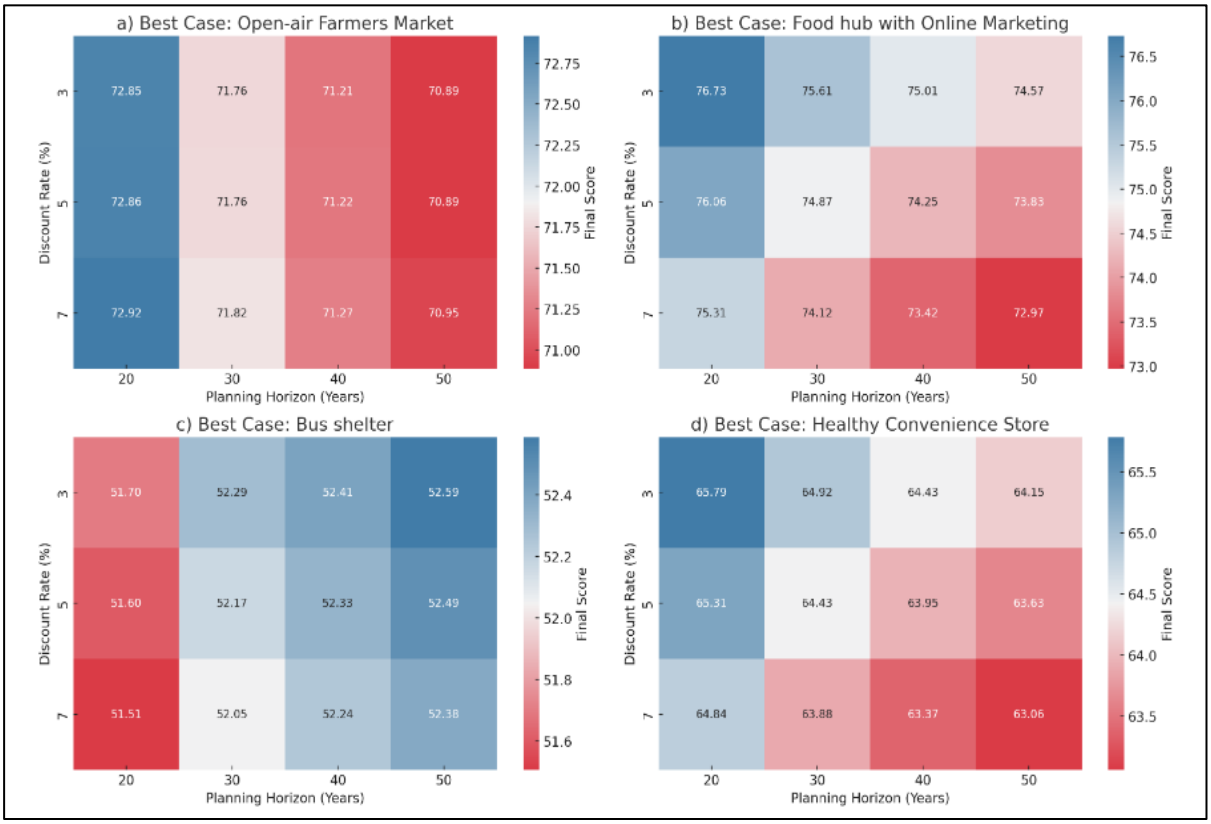

Figure C5: Heatmap for the final scores of each alternative candidate regarding different discount rates and planning horizons for the best-case scenario.

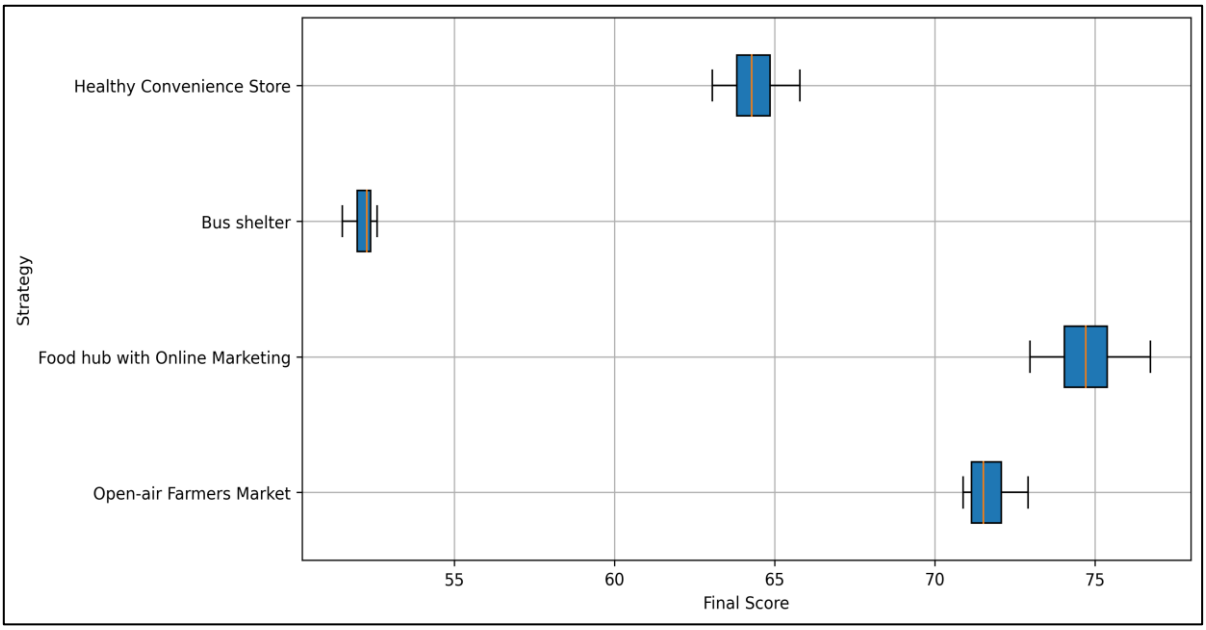

Figure C6: Final score ranges for each alternative based on the variation on DR and HP for the best-case scenario.