2024

Exploring the Need for Community Gardens in Licking County, Ohio

Jacob Eppley

Exploring the Need for Community Gardens in Licking County, Ohio

Jacob Eppley

Project Advisor: Anthony Bonifonte

Department of Data Analytics

Denison University Summer Scholars
2024

Abstract

Across America, millions of households suffer from food insecurity and are unable to provide adequate meals for the family. Through financial and physical constraints such as time and distance to stores, food deserts are formed that severely limit the options available for these food insecure families. In many cases, fresh produce can become an afterthought on the grocery list which results in a lack of consumption of these healthy foods. One viable option for improving access to fresh produce is the use of a community garden where residents have access to freshly grown produce and receive various social benefits. In this research, we worked with Together We Grow Gardens (TWGG) in Licking County, Ohio, to examine factors of financial and physical need for community gardens within the county. We identified areas within the county that showed the most perceived need for a community garden, with TWGG selecting a location for future development. We then demonstrated how these methods can be generalized by expanding to all of Ohio for a county-by-county analysis of where the most perceived need is within each county.

1. Introduction

1.1 Food Insecurity/Food Deserts

An American family described as food insecure is defined as being “uncertain of having or unable to acquire enough food to meet the needs of all [family] members because [of] insufficient money or other resources for food” (Rabbitt, Hales, Burke, & Coleman-Jensen, 2023). One possible cause of families facing food insecurity is living in a food desert; “areas of relative exclusion where people experience physical and economic barriers to accessing healthy food” (Shaw, 2006). This often manifests as a lack of access to fresh food options from grocery stores and supermarkets due to economic or physical barriers. The Rabbitt et al. report showed that 12.8% of households in America (roughly 17 million) experienced some level of food insecurity in 2022. This was a statistically significant increase compared to the 10.2% of US households (roughly 13.5 million) that experienced food insecurity in 2021. All types of households regardless of marital status, number of children, age, race/ethnicity, level below the poverty line, and location of residence saw an increase in food insecurity from 2021 to 2022, and nearly every increase was statistically significant.

When comparing census tracts identified as food deserts with other census tracts using the United States Department of Agriculture’s (USDA) Food Access Research Atlas, higher levels of poverty, lower income levels, and lower education levels are often present and highly correlated with each other. Populations in food deserts tend to be less dynamic, meaning people are not able to move out of food deserts and they are not attractive places for people to move into

(Dutko, 2012). With limited ability to escape food deserts, it is critical to meet the nutritional needs of communities in these areas. In this research, we suggest community gardens as a viable option to combat food insecurity and food deserts while implementing methodology to effectively choose the location of community gardens at the county level.

1.2 Past Research

A study conducted in Rockford, Illinois highlighted how consumers are forced to make decisions when it comes to buying groceries (Furness & Gallaher 2018). With limited money and time cited as common issues by consumers who visited the Rock River Valley Pantry –a food pantry in Rockford– choices had to be made when shopping for groceries. Shoppers often placed higher priority on foods considered to be "staples" of a diet and purchased items such as meat, milk, and bread before considering produce options. Fresh fruits and vegetables often became an afterthought on the grocery list and were often left off due to a lack of money after these purchases. However, at the food pantry where fresh produce was freely available, a majority of customers took fresh fruits and vegetables.

One of the methods used in Rockford to supply the food pantry with fresh produce was growing food in community gardens. A majority of these gardens were placed around the city and maintained by volunteer gardeners who would grow, harvest, and donate the food to this pantry. Other gardens served as areas for community members to rent plots and grow the produce of their choosing, providing varied options for customers to consume the produce of their choosing. With a wide variety of fruits and vegetables available from the gardens, customers were able to consume a diverse diet of produce that has been linked to lower risks of chronic diseases. The national consumption of fresh produce in the US is below the recommended values

and community gardens allow for more consumption along with diverse offerings for increased health benefits (Liu, 2013).

Beyond the benefits of increased access to fresh produce, community gardens also offer opportunities for bonding, safety, and justice. Studies conducted in Baltimore, Maryland and Denver, Colorado, showed how residents grew stronger connections to one another through gardens. In Baltimore, the Duncan Street Miracle Garden serves a community where 42% of residents reside below the poverty line. These gardeners follow a philosophy of community food service which focuses on the well-being and food security of the community as opposed to the individual. Working together for the betterment of each other resulted in a growing sense of community and the opportunity for residents to learn from each other and work together towards a common goal (Corrigan, 2011). In Denver, there were similar feelings among the gardeners towards working together and benefiting from the community setting. Working together in a garden allowed for advice and help to be freely exchanged and for bonds among the gardeners to be created. Feelings of trust and safety grew within the gardeners as a result of this community setting, and, when decisions need to be made, opportunities for leadership as well as community collaboration manifested from the gardens (Teig et al., 2009).

1.3 Community Partner: Together We Grow Gardens

This research is conducted in partnership with Together We Grow Gardens (TWGG) and strives to find where the most need exists in Licking County for a new community garden. TWGG started in 2012 with one community garden in Newark, Ohio, and has since grown to six total gardens with five in Newark and one in Utica, Ohio. In their gardens, TWGG provides two main ways for the community to obtain produce. Community members are able to rent out their

own plots at any of the gardens in addition to “U-Pick” options available at three of the gardens in Newark. U-Pick plots allow for any member of the community to harvest fresh produce completely free of charge during the summer months (Together We Grow Gardens).

TWGG and Newark are situated in Licking County, Ohio (highlighted on Figure 1), a suburb of Columbus, Ohio. Per the 2020 Census, Licking County is the third largest county in Ohio based on area and has a population of 178,519 people. Licking County’s median family income ($76,654) is nearly $11,000 higher than the Ohio median family income ($65,720) and the poverty rate (10.2%) is over 3% lower than the state average (13.4%). Even with a noticeably higher family median income and lower poverty rate compared to the rest of the state, the largest city in Licking County, Newark, finds itself lagging behind in both variables. Accounting for roughly 50,000 residents, Newark saw much lower median family incomes per the 2022 Census ($56,284) and a higher poverty rate in the ACS 5-year Estimate (16.3%).

As measured by the USDA, Census tracts within Licking County –specifically Newark– show indications of food insecurity and suggest locations where community gardens could be helpful. Compared to the rest of Ohio, Licking County contains at least one census tract in the 90th percentile of poverty rates, SNAP usage, percent of residents with the highest education level of a high school diploma, no access to a vehicle, and bottom 10th percentile for median family income (US Census Bureau, 2019). Based on previous research conducted by the USDA that demonstrates each factor being linked to food insecurity, this motivates the need for more community gardens in Licking County with special consideration for Newark.

Multiple tracts within Newark are flagged as having limited access to food and lower income among residents. This marks a tract as susceptible to being a food desert. In order to be flagged as lower income, the tract must have a poverty rate of at least 20% or a median family

income that is less than or equal to 80% of the state median family income. For limited access, a tract must have at least 500 people or one-third of the population be over 1 mile from a grocery store in urban areas or over 10 miles from a grocery store in rural areas (USDA, 2021). While the county as a whole seems to be doing fairly well compared to the rest of the state in terms of these metrics, the county's largest city is proof of food security struggles persisting within Licking County.

TWGG is aware of this food insecurity most pertinent in Newark, and through conversations with their CEO and Garden Director they directly addressed that the current gardens are placed due to the area's need for fresh produce. However, given the present need in Newark along with the fact that all gardens are planted at full capacity, we are still fully considering Newark as a possible location for a new garden along with the rest of Licking County.

Figure 1: Ohio county map with Licking County highlighted

2. Data and Methods

2.1 Population Density

Population data was obtained from the Global Human Settlement Layer (GHSL) dataset GHS-POP R2023A - GHS Population and measures population density by mapping global population estimates for 2025 onto a grid. Through an examination of census population data and geography data, the GHSL population dataset is able to effectively model population density. We chose to use population density because it is important to place the garden where it can

conveniently be accessed by residents. As previous research showed, the time and distance to a grocery store is a critical factor for food insecure families. By utilizing population density, we will know where the populated areas of Licking County are and which garden locations will be easily and quickly accessible. The grid created from the population density data provided the units utilized to map all of our variables together.

2.2 Grocery Store and Garden Distance Calculation

Distance from each point to the nearest grocery store is used to determine which areas are farthest away and show which areas of Licking County require longer journeys to the store. In this calculation, we limited our data to stores classified as “grocery stores” or “supermarkets” given a Google Maps distinction and our own personal judgment. Thus, smaller stores with severely limited food options such as convenience stores and dollar stores were not considered when calculating the distance to the nearest store. This was done because convenience/dollar stores do not have enough healthy, fresh offerings to classify a family as food secure.

To calculate this distance, we obtained the Euclidean distance to the closest grocery store from each point (visualized in Figure 3). It is worth noting that the scope of the grocery store locations was expanded beyond Licking County since, near the border, the closest grocery store may be outside of the county. This can be seen in the southwest corner of the county in Figure 3 where multiple stores are just outside the county line.

For the community gardens, we followed the same process to calculate the distance to the closest garden. In this calculation, we included community gardens in addition to TWGG gardens since we are concerned with the community’s access to any viable garden. This added a garden in Granville, two in New Albany, one in Reynoldsburg, and one in Pickerington in

addition to the TWGG plots. However, with a majority of TWGG's gardens in Newark, it is unsurprising that a vast majority of the county finds itself relatively far from a garden.

2.3 Poverty Rates, SNAP Usage, and Free/Reduced Lunch by School District

Poverty rate, SNAP usage, and rates of free/reduced lunch were utilized for the purpose of assessing where the most financial need for community gardens lies. As stated in previous research, money, along with time and distance, can be a critical factor for families deciding which groceries to buy. Each of these factors provides insight into the financial restrictions of residents while also providing overlapping geographies that allow us to create a more granular view of perceived need. Poverty rate measures the proportion of people below the federal poverty line while SNAP usage measures the proportion of people receiving SNAP benefits and school district free/reduced lunches measures the proportion of students who qualify for free or reduced cost lunches at school. Poverty rates and SNAP usage were obtained from the 2019 US Census and free/reduced lunch rates were obtained from October 2023 (FY2024) Data for Free and Reduced-Price Meals from the Ohio Department of Education and Workforce. Geography data for census tracts and school districts came from the US Census TIGER/Line Shapefile Dataset. Threshold numbers for poverty rate, SNAP benefits, and free/reduced lunches can be viewed in Tables 2-4 in the Appendix Section 1.

The process of calculating poverty rate, SNAP usage, and free/reduced lunch rates followed a very similar process. In order to calculate each value in Licking County, we utilized a grid with the same dimensions of the population data grid so that we could map our variables in the same format. In this grid, we took each point and checked which geography it belonged to,

repeating the process for our three different variablesUsing different geographies allows for overlap within the data and will give a more precise picture of where the most perceived need is (individual variables are viewable in Figures 4-6).

2.4 ALICE (Asset Limited, Income Constrained, Employed) Data

Through conversations with staff at TWGG, it was suggested that we utilize ALICE rate in tandem with our other factors as a way of expanding beyond the poverty line. ALICE is intended to represent employed residents who earn more than the federal poverty line but still do not earn enough to afford the basic necessities where they live. ALICE works by calculating how much a person/family would need to spend on everyday expenses (housing, food, transportation etc.) based on the area they live in. This calculation provides a more accurate report of people who cannot afford to live in an area as opposed to the poverty line which is a flat rate anywhere in the country. For example, in more expensive areas to live, ALICE would recognize more people as struggling to make ends meet even if they are above the poverty line. ALICE measures allow us to get a better understanding of where the need is that the poverty line does not fully cover. We recorded the total number of households living below the ALICE line at the township level from the United for ALICE 2022 Ohio Data Sheet. Following the same process of geography checks utilized in Section 2.3, we were able to collect ALICE data for each township. Now with three different geographies, a more granular view of perceived need is achieved. Township geography also came from the US Census TIGER/Line Shapefile Dataset.

2.5 Weighting the Factors

To consider all of the variables for this research (population density, census poverty rates and SNAP usage, school district free/reduced lunch rates, the proportion of ALICE households, and distance to grocery stores/community gardens), we utilized a weighting approach based on TWGG expert opinion. Given the multiple geometries used by the data, we created overlap between school districts, census tracts, and townships which allows for a highly granular view of perceived need. We normalized each variable by calculating how many standard deviations each point was away from the average value for that variable so that each factor would be on a consistent scale with the others and able to be combined. Combining the normalized, weighted scores allows for a comprehensive view of perceived need within the county. We then weighted each value based on conversations with TWGG staff and what they prioritized for a new garden location. This resulted in a final weighted formula:

$$\frac{3}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{3}{20}x_{pov} + \frac{2}{20}x_{SNAP} + \frac{2}{20}x_{ALICE} + \frac{2}{20}x_{garden\ dist} + \frac{7}{20}x_{store\ dist}$$

This final formula reflects the ranking of TWGG staff and also aligns with the previous research on food deserts and food insecurity. Distance/time of travel was noted in Furness & Gallaher's study as a barrier for people going to the grocery store for produce and was the top priority for TWGG, so it received a high weight. School district free/reduced lunch rates, poverty rates, SNAP usage, and ALICE households were utilized in a similar manner to understand the proportion of people who may not be able to support a healthy diet financially over different geometries within the county (school districts, census tracts, and townships). Each of these weights were kept relatively low since they are measuring similar financial variables. Distance to

the nearest garden has a lower weight since a majority of the county is not near a garden and putting gardens in close proximity is not a prohibitive factor. Since population density in Newark compared to the county is much higher and it was not listed as a major factor for TWGG, it was given the lowest weight as to not skew the final score towards this dense population. We conducted sensitivity analysis with different weights, further explored in Section 4. Different scaling systems generally resulted in similar indications of where the most need is.

3. Results

Figures 2-8 below show the mapping of individual factors we considered in Licking County. Figure 2 shows the population density of Licking County while Figures 3 & 4 show the distance from each point to the nearest grocery store and community garden respectively.Figure 5 displays poverty rates and Figure 6 displays SNAP usage rates across the census tracts. Figure 7 displays the proportion of students on free/reduced lunches in each school district and Figure 8 shows the proportion of ALICE households in each township.

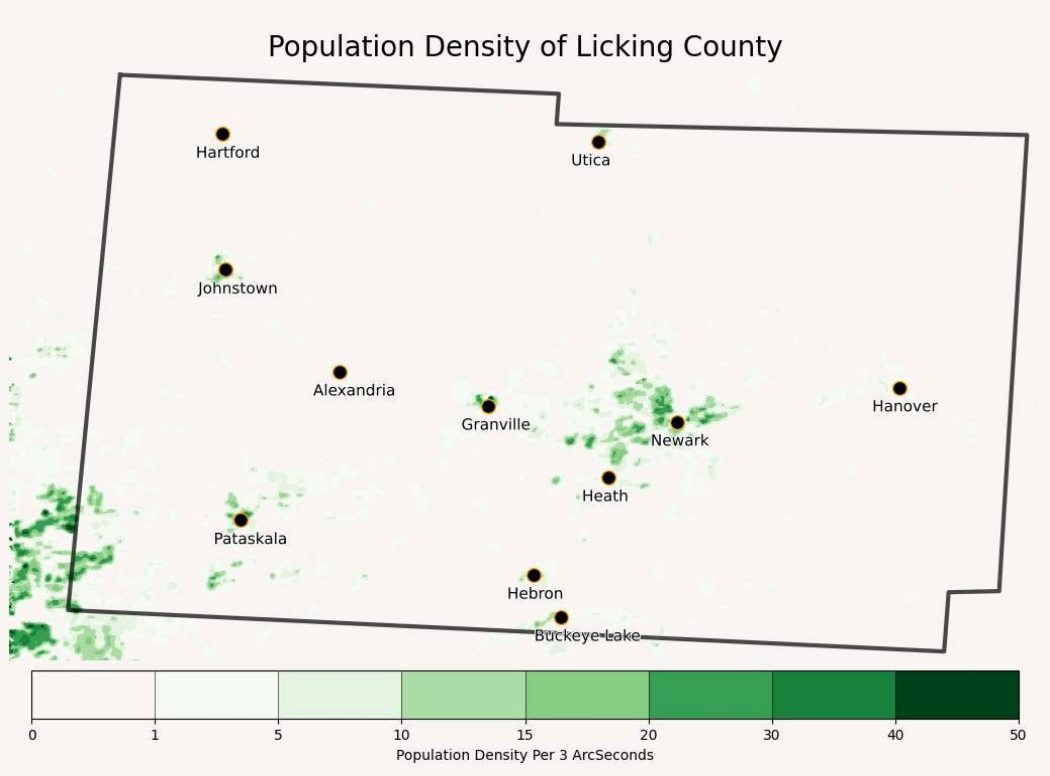

Figure 2: Population density of Licking County

Figure 3: Distance to the nearest grocery store

Figure 4: Distance to nearest community garden

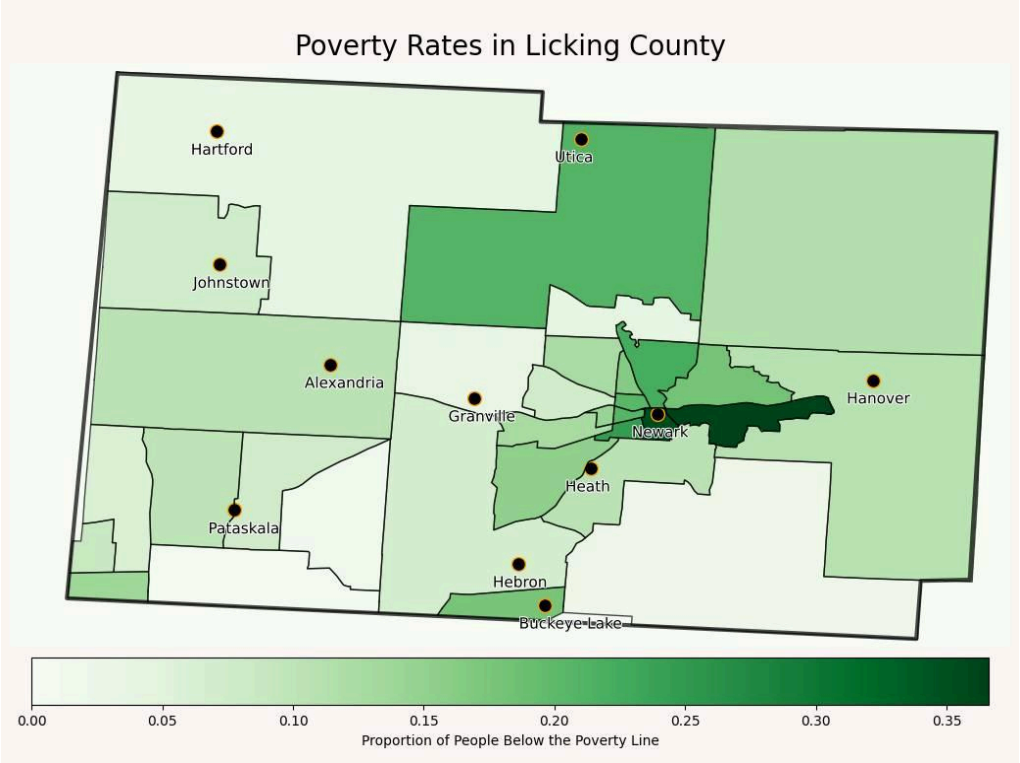

Figure 5: Poverty rates by census tract

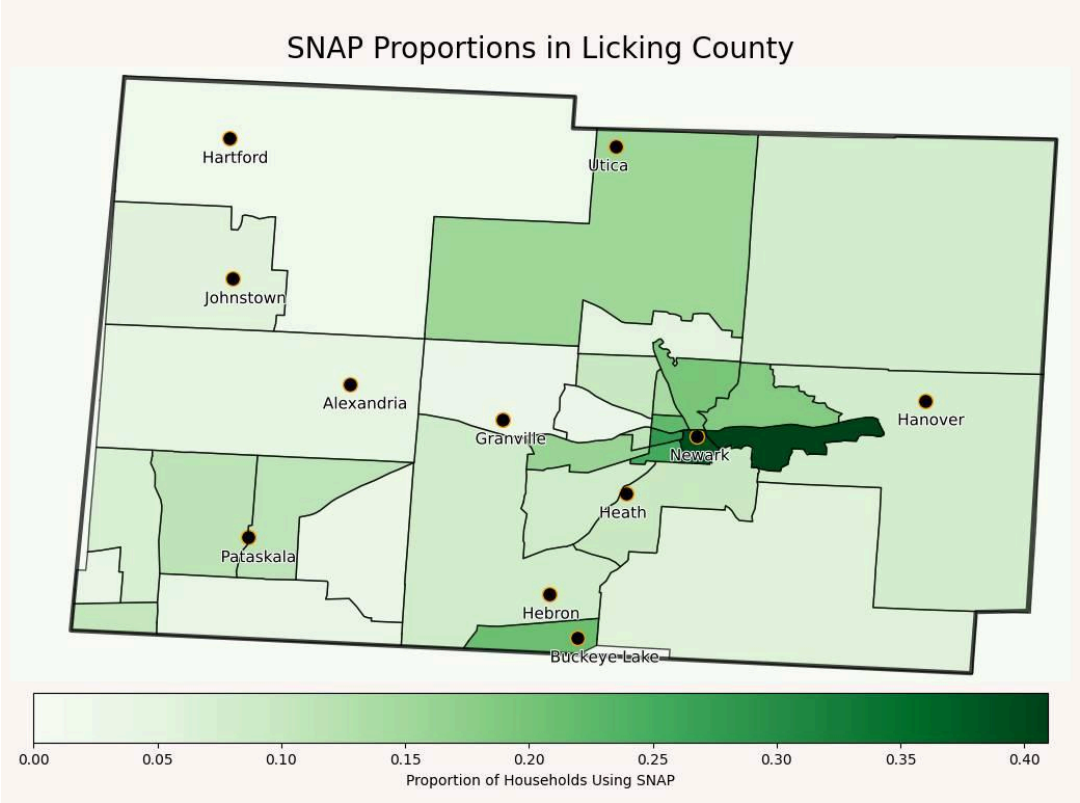

Figure 6: SNAP usage rates by census tract

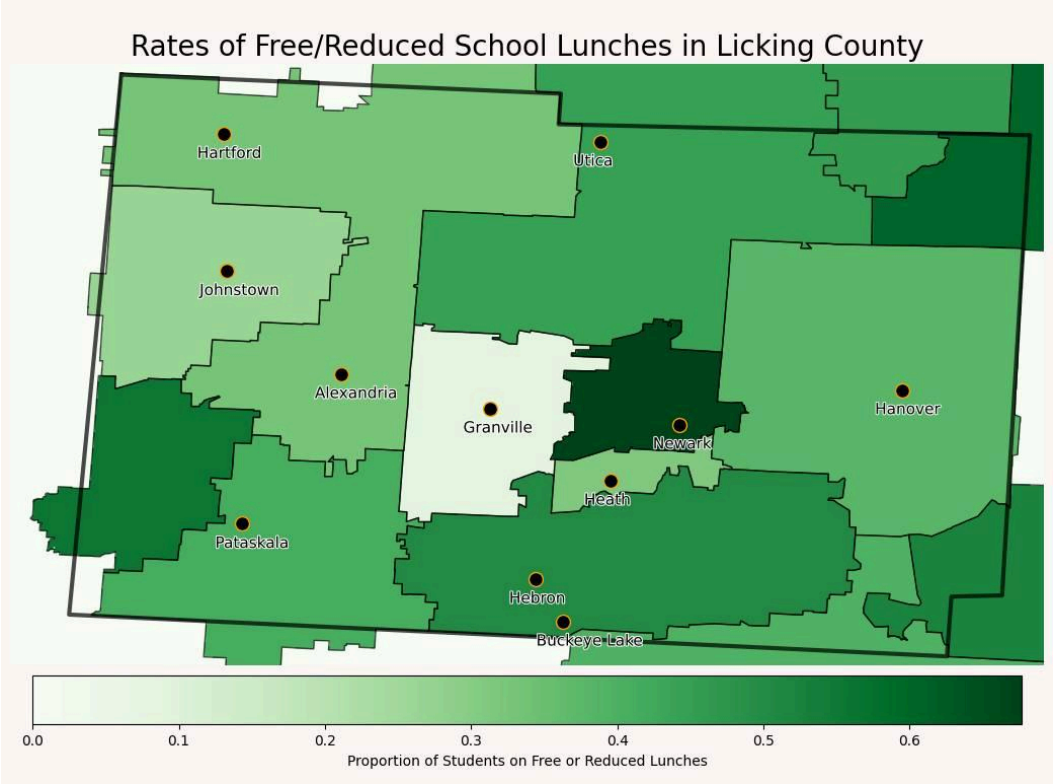

Figure 7: Proportion of students getting free/reduced lunch by school district

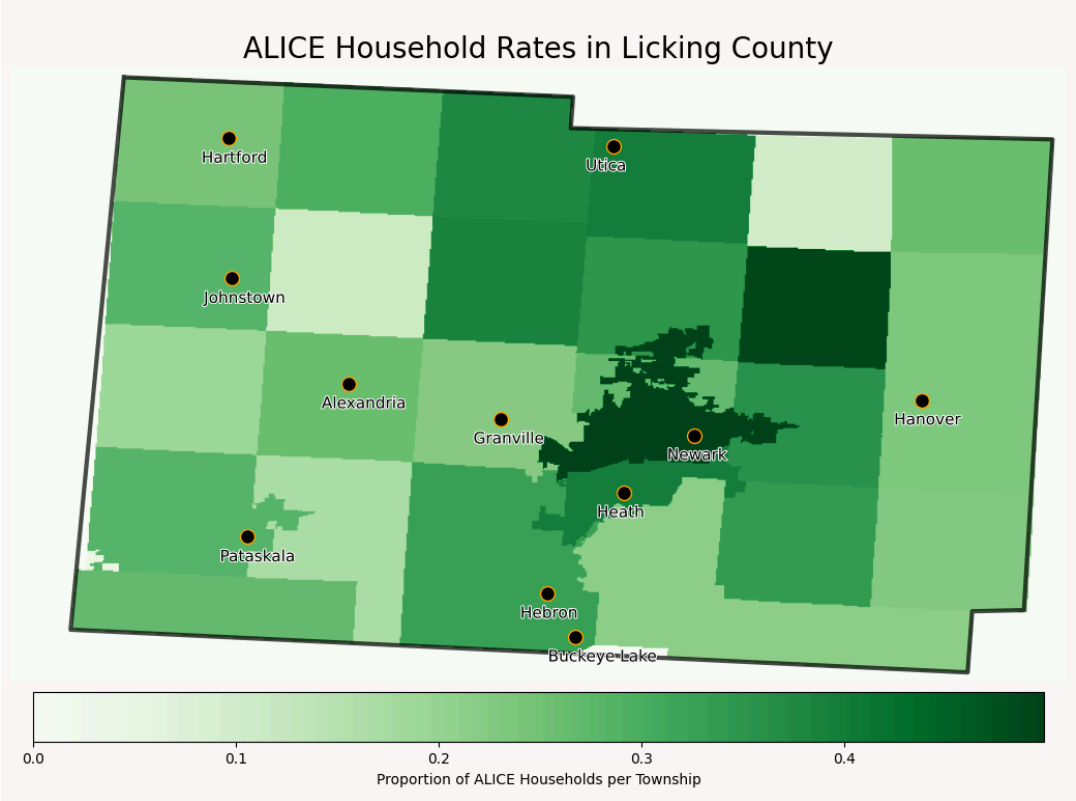

Figure 8: ALICE household rates per township

Following the normalizing process and weighting formula as described in Section 2.5, Figures 9 & 10 capture the final scores of our research with Figure 9 displaying all of Licking County and Figure 10 focusing on Newark. Most of the highest need areas are indicated in Newark, specifically around the south side and to the east side reaching out near Hanover and the small town of Marne. A majority of TWGG gardens are in this southern area which indicates that they are in places where the need is high. However, as discussed previously, given the facts that there is still a perceived high need and that the gardens are operating at full capacity, this area is still in consideration for a new garden. Other areas of the map indicating higher need are the area north of Granville and northeast of Alexandria. We can also see the map begin to darken near

Buckeye Lake, indicating potential need in that city. The last area indicating greater need is the bottom right corner of Licking County. For clarity purposes and ease of understanding in Section 6, we included Figure 11 as a reference map for the areas we mentioned here.

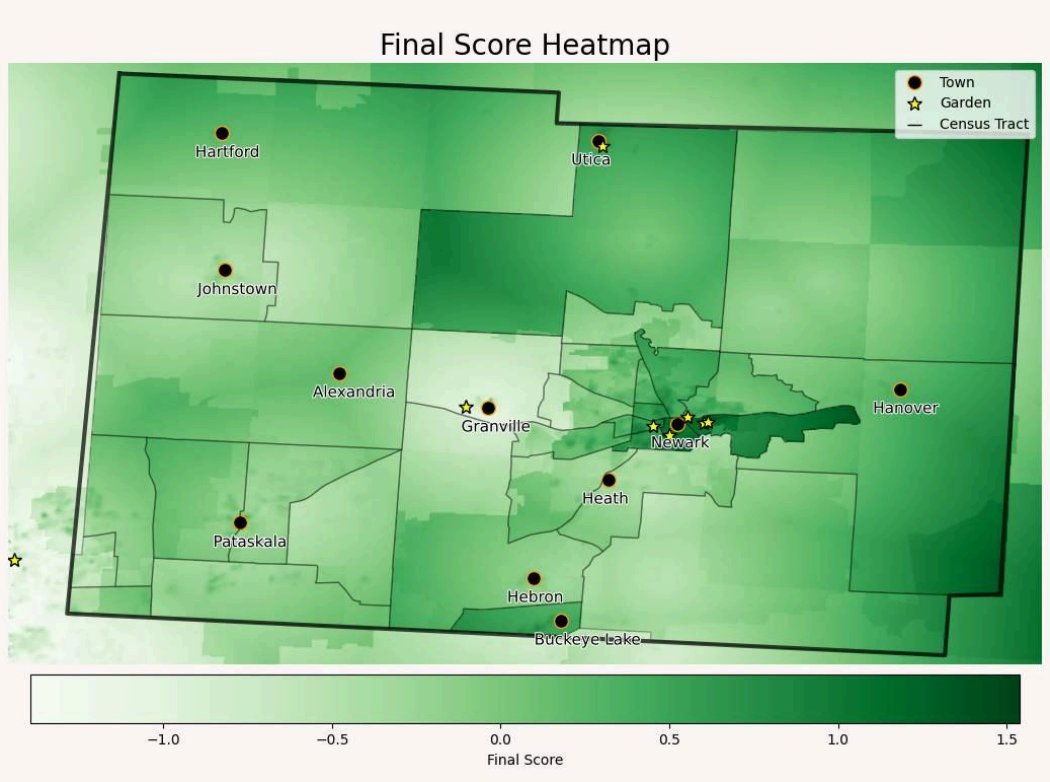

Figure 9: Final scoring metric across Licking County

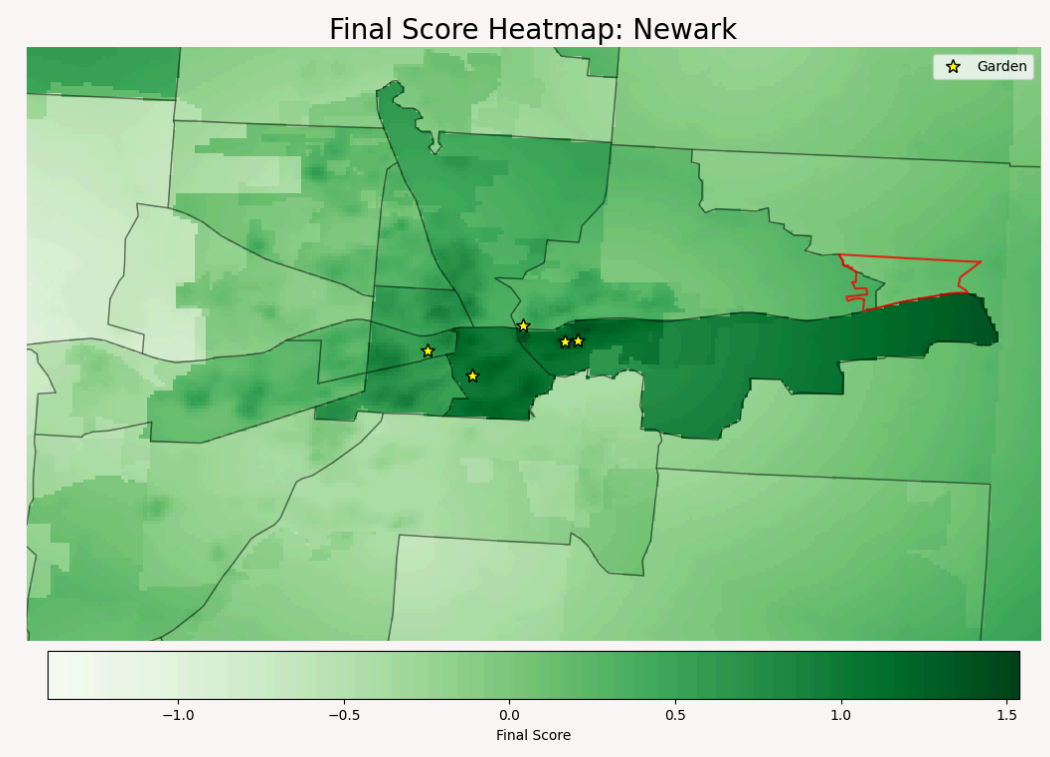

Figure 10: Final scoring metric across Newark with Marne outlined in red

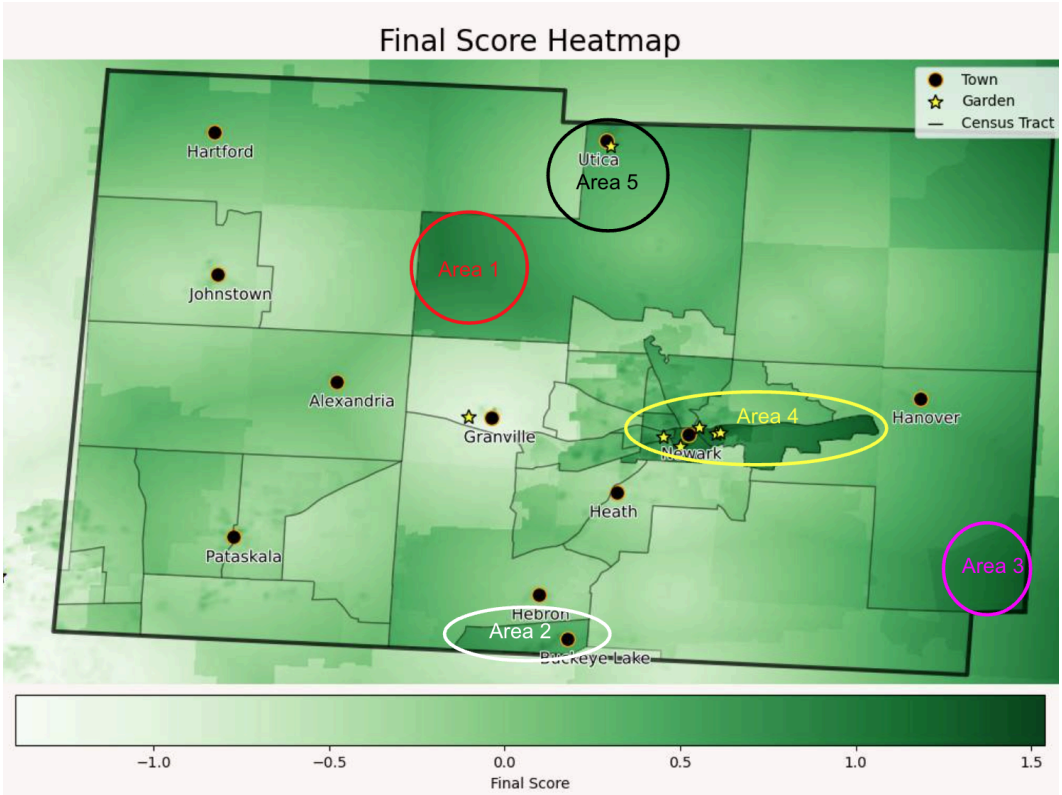

Figure 11: Final scoring metric heatmap with areas of interest circled for reference

Table 1 below ranks the average final scores of various towns within Licking County. Town averages were obtained by averaging the final score values within each town boundary. Observing the table, we can see that the highest average need can be found in Utica, Buckeye Lake, and Newark. We are able to observe these highest values in Figure 11 as Areas 2,4 and 5 of most need. Johnstown and Granville are both areas of relatively low need, even though they are more population-dense areas of the county. Both have close access to at least one grocery store and have relatively low rates of poverty, SNAP usage, and students receiving free/reduced lunch. These factors specifically mark these towns as lower need for a community garden.

Town	Average Score
Utica	0.52
Buckeye Lake	0.39
Newark	0.34
Alexandria	0.19
Marne	0.16
Pataskala	0.01
Heath	-0.21
Johnstown	-0.39
Granville	-0.78

Table 1: Average perceived need score across Licking County towns

4. Sensitivity Analysis

In order to evaluate the effectiveness of the weights we chose, we ran multiple variations of the weighting formula with different weights assigned to each variable. In each iteration of the analysis, we chose a different focal variable to see if emphasizing different characteristics of food insecurity and community gardens significantly altered our results. This resulted in each variable receiving the highest weight at least once through our iterations of the sensitivity analysis.

Across all of the formulas (viewable in Appendix Section 2), areas of southern and eastern Newark are consistently showing the highest perceived need. Additionally, other areas we noted, specifically Buckeye Lake and the area north of Granville, appear as higher perceived need areas in multiple iterations of the formula. Granville, the town with the lowest average need in our initial formula, consistently shows lower perceived need across the different formulas which again indicates reliable insight from our initial formula. We are seeing some variation across the formulas in the areas being marked given the different weights. This is to be expected - as we prioritize different factors, we are naturally going to see slight variations in each formula. Given the expert opinion and consistency in highest/lowest need areas being marked, we believe our formula is reliably marking areas of perceived need.

5. Generalizing Statewide

5.1 Variable Alteration

Upon the completion of the research for TWGG, we expanded the scope of our project to consider all 88 counties in Ohio in order to determine where the greatest need for a community garden is within each county. Throughout the expansion of the scope, the methods for each county remained largely the same. For poverty rate, SNAP usage, ALICE rate, and school district lunch data, we used the same methods for assigning values as described in Sections 2.3 and 2.4.

In regards to other variables, the process needed to be altered significantly. Regarding the distance to the nearest garden variable, we ultimately decided to remove this variable as it is unrealistic for us to account for every community garden in the state of Ohio. There is no accurate data collection we could find that included coordinates or locations of community gardens around the state. Potential data sources found were generally unreliable. For example, a dataset found from web scraping claimed that Newark only has one community garden when we know that is not true. Data collection for community gardens described in Section 2.2 required manual searching and is not feasible when covering a larger geography such as a state. With an invalid alternative and limited importance from TWGG, the variable is not to be considered.

Our variable of distance to the nearest grocery store required extensive manual input as well, as we got all of our coordinates from manual searching on Google Maps. APIs could provide a feasible solution, however through scraping with APIs we conducted, this was found to be unreliable. Multiple stores that did not meet our grocery store criteria were included in addition to various restaurants and other food vendors. The use of an API would require

extensive manual work to the point that other options are more efficient when dealing with such a large area. From the USDA Food Access Research Atlas, there are variables for census tracts that identify as Limited Access (as mentioned in Section 2). We utilized the Limited Access variable to account for those who are farther away from grocery stores. While it is not as granular as the continuous scale used previously, it will still provide insight into how accessible food is.

5.2 Statewide Heatmaps

Expanding to the state level with altered variables, we found it necessary to reconsider the weighting formula we used previously. While considering the suggestions of TWGG staff and changing values to account for different variables, our weighted formula for this section resulted in:

$$\frac{5}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{4}{20}x_{pov} + \frac{3}{20}x_{SNAP} + \frac{4}{20}x_{ALICE} + \frac{3}{20}x_{LA}$$

This formula was based on our discussions with TWGG, and prioritizes the factors that suggest limited financial income. We kept population density relatively low not only due to the recommendations from TWGG but also due to the fact that very population-dense cities could easily be skewed if this weight was higher. The main differences in the weighting scheme come from the increased weight of school district data and the limited weight of access to grocery stores (in comparison to our distance to grocery stores variable). In regards to school district data, we chose to increase this weight for increased granularity. Without the continuous distances to gardens variable and grocery stores now being recorded by census tract (as Limited Access), a majority of our factors were grouped by census tracts, resulting in a loss in granularity. Increasing the weight of school district data results in more prominent distinctions within each

census tract which is why we chose a higher weight. Likewise, the access to grocery stores was weighted lower due to this geometry and the fact that it is no longer a continuous variable. Additionally, since this variable simply identifies if a tract has limited access or not, data is stored as either 1 or 0 and is not normalized like the rest of the data. Given these changes, we did not want to overweight this factor and make census tracts the dominating geography with a loss of granularity. Rates of free/reduced lunch still capture a similar financial need, so we are still able to capture the same broad measure with increased granularity in the final maps. Using this formula across each county, we created heatmaps displaying the perceived need within every county in Ohio. Examples of these maps can be found in Appendix Section 3 and every map can be found in a GitHub repository linked in Appendix Section 3.

6. Discussion

6.1 TWGG Implementation of Results

Based on the results of the scoring, we have five main areas highlighted above in Figure 11 that we will focus on. Upon review of the five total areas with TWGG, Areas 1 and 3 were the first to be removed from consideration. These two areas were excluded for two main reasons; a lack of people in the areas and the distance to TWGG's main office in Newark. Both areas have very low population densities, which means it would not be practical for a garden to be placed in either spot when we consider the conditions that create food deserts and food insecure families. Distance and time to travel are shown through research to be major contributors, so placing a garden that requires extensive time for a majority of gardeners to reach is not ideal. For TWGG employees, each of these locations would be 20+ minutes from the main office, which would

provide significant difficulties for employees maintaining the garden. For a garden to be maintained this far away, assistance from the local community in maintaining the garden is necessary and why the garden in Utica is able to operate.

Comparing the final three areas, TWGG chose Area 4 as the best location for a new garden. Area 4 indicates a higher level of perceived need in our total score rankings and, when looking at the variable maps individually, some of the highest rates of our chosen variables appear in Area 4. With this selection, it is important to acknowledge that there is a perceived need in Areas 2 and 5. They are both relatively densely populated and Area 2 would be an opportunity for TWGG to expand into a new area of Licking County. However, when considering the final score and the individual values of our variables, Area 4 presents the most need within the community and is ultimately the desired location for TWGG. Even with Utica/Area 5 containing the highest average value of our final score, parts of Area 4 have the highest values of the map, indicating a more granular area of need within Newark. Posing similar problems as Areas 1 and 3, both Area 2 and Area 5 would require 20+ minute drives from the TWGG office.

Within Area 4, there is one specific area we noted with TWGG that they identified as a potential location for a new garden. This is the eastern part of Area 4 where need is high and there currently are no gardens nearby. Very near this area, TWGG identifies the small town of Marne (outlined in red in Figure 9) as a feasible location for a new garden. While it is not in the census tract that measures the darkest green on our map, it lies on the northern border of the census tract meaning it could still be accessible for those in the tract that need it along with an established population in the area. This would provide a second opportunity for TWGG to

expand outside of Newark and at limited effort, as the travel time from the TWGG office to Marne is 5-10 minutes; comparable to the existing gardens in Newark.

We recognized with TWW that a community garden could still benefit Areas 2 and 5. Both areas display a higher perceived need with relatively dense populations (compared to the entire county), and there is already a successful TWGG garden in Utica. We believe that these areas are still worthy of consideration for a new community garden but do not show the most perceived need within the county.

6.2 Limitations

Throughout the research process, we identified multiple factors that could present limitations on the findings. One limitation when we consider where gardens should be located is that we did not take into account green space people own that would allow them to plant their own gardens. It is conceivable that a community garden would be more valuable in a location where there is not a lot of green space –such as near an apartment complex– since there is no opportunity for people to grow their own food, as opposed to households with yards large enough to plant their own gardens. Incorporating this could help add to the population density as it could tell us where the people are who cannot plant their own gardens.

Though mentioned in previous research, we decided not to include education level, vehicle access, or median family income as factors in our scoring algorithm. While we recognize these are important factors when it comes to addressing food insecurity, we believe that they were not necessary for this research. Regarding the vehicle access data, we did not include this specifically because the census tracts with the highest proportion of people without vehicles were those in downtown Newark where grocery stores were close and most abundant. With multiple

options close by, we believe the constraints (poverty, SNAP) that limit customers' ability to buy food were more important in this case than physical access to the grocery store. Additionally, education level, vehicle, and median family income data had a high correlation across the census tracts with poverty rates and SNAP usage. As not to overweight this factor and the census tract geography they were not included in our final research.

Another aspect of the study we were not able to fully consider were the attitudes and feelings of gardeners who own plots and participate in U-Pick. In our current study, we consider the perceived need based on factors in past research and insight from experts at TWGG. Future studies could survey the gardeners themselves to ask why they use the garden and how far they travel to get there. Surveys could also be helpful to gauge interest in a potential location. Our method only captures the perceived need of a community and does not consider the residents' feelings or interests towards having a community garden in addition to their physical abilities to potentially maintain a garden plot. Ultimately, due to the time constraints of the project and the privacy of the gardener's information such as addresses, we were unable to incorporate their opinions into our formula but recognize the importance they could hold in future research.

6.2.1 Statewide Limitations

The main limitations that came from expanding our scope statewide were missing or incomplete data. Some data was missing for nearly all of our factors and results in some counties not having all of the factors as a part of the scoring. However, as discussed with the variables we decided to leave out in Section 6.2, we do not believe this invalidates our results. Given the multiple geographies, we do not have areas of maps that are completely missing data and are only missing one factor at a time. This is most prominent in the school district data where

changes to school district zoning and lack of reporting at every school causes multiple districts to be incomplete.

To handle this missing school district data, we utilized mean interpolation in the normalization process. For each county, we calculated the normalized scores of the districts we had data for. We then set each missing school district value to 0 after this normalization so that it was equivalent to being equal to the average school district value. We believe that mean interpolation along with our other factors are able to effectively measure the perceived need in an area due to the fact that we have multiple factors measuring financial need along with school districts. Given the highly-correlated nature of these variables, areas that have higher rates of free/reduced lunch generally have higher poverty, SNAP, and ALICE rates as well. While we are missing some precision in the school district data, the mean interpolation gives an estimate of what the value is and our additional variables provide adequate information to the perceived need of the area.

Additionally, we were unable to achieve the same level of granularity for distance to grocery stores, and, while the limited access tracts provide an alternative, it is not as specific as what we obtained with the manually collected Euclidean distance to each grocery store. We were also not able to collect data on gardens statewide, and as a result were unable to account for existing community gardens in the area. Meaningful insight into the perceived need of community gardens can be obtained from these results, however organizations should refine these estimates in light of these limitations before implementing our solutions.

With the expansion of scope to the entire state, we risk having our weighting system lose some of its accuracy as the expert opinions from TWGG likely do not apply to the entire state. Licking County does not contain cities anywhere near as large as Columbus, Cleveland, or

Cincinnati which could result in an inaccurate weighting system for these areas. It is conceivable that factors for opening community gardens identified by TWGG are not the factors of most concern in other counties with vastly different city and town makeup within them. Without this local input, it is conceivable that we are not properly weighting the factors of greatest concern within each county and thus do not have the most accurate identification of need. Additionally, other factors we mentioned like vehicle usage or median family income may be more important for identifying perceived need in other areas. If applied at a specific county level, it would be critical for further research to consult with experts on what the factors of greatest importance are in each area for adjustments of the formula.

7. Conclusion

Community gardens provide various health and social benefits and can be a key piece of fighting food insecurity. This research provides a feasible strategy for discovering the areas of highest need within a county for a community garden. Combining thoroughly-researched indicators of food insecurity and food deserts, we were able to create a process of mapping the areas of highest need within each county of Ohio. Through this process, we were able to work with TWGG and provide multiple options for a new community garden and create an opportunity for the most impactful growth within the community. Beyond Licking County and Ohio, our research provides a practical process that can identify areas of perceived need in other geographies.

8. Acknowledgments

I would like to express my thanks to Dr. Bonifonte of the Denison University Data Analytics Department for his constant guidance and support which made this research possible. I would also like to thank the Lisska Center at Denison University for funding through the Paul R. Ashbrook Endowed Fund. I would also like to thank Together We Grow Gardens for offering advice and expert input throughout the duration of the project and for the opportunity to conduct this research with the organization.

Appendix

1. Poverty, SNAP, and School District Free/Reduced Lunch Requirements

Poverty

Number of People in Household	Yearly Income
1	$14,580
2	$19,720
3	$24,860
4	$30,000
5	$35,140
6	$40,280
7	$45,420
8	$50,560

Table 2: Yearly maximum income to be below the federal poverty line

SNAP

Number of People in Household	Yearly Income
1	$19,578
2	$26,572
3	$33,566
4	$40,560

5	$47,554
6	$54,548
7	$61,542
8	$68,536

Table 3: Yearly maximum income to qualify for SNAP benefits in Ohio

School District

Number of People in Household	Yearly Income
1	$27,861
2	$37,814
3	$47,767
4	$57,720
5	$67,673
6	$77,626
7	$87,579
8	$97,532

Table 4: Yearly maximum income to qualify for free/reduced lunches

2. Sensitivity Analysis

Sensitivity Formula 1

$$\frac{2}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{6}{20}x_{pov} + \frac{3}{20}x_{SNAP} + \frac{4}{20}x_{ALICE} + \frac{2}{20}x_{garden\ dist} + \frac{2}{20}x_{store\ dist}$$

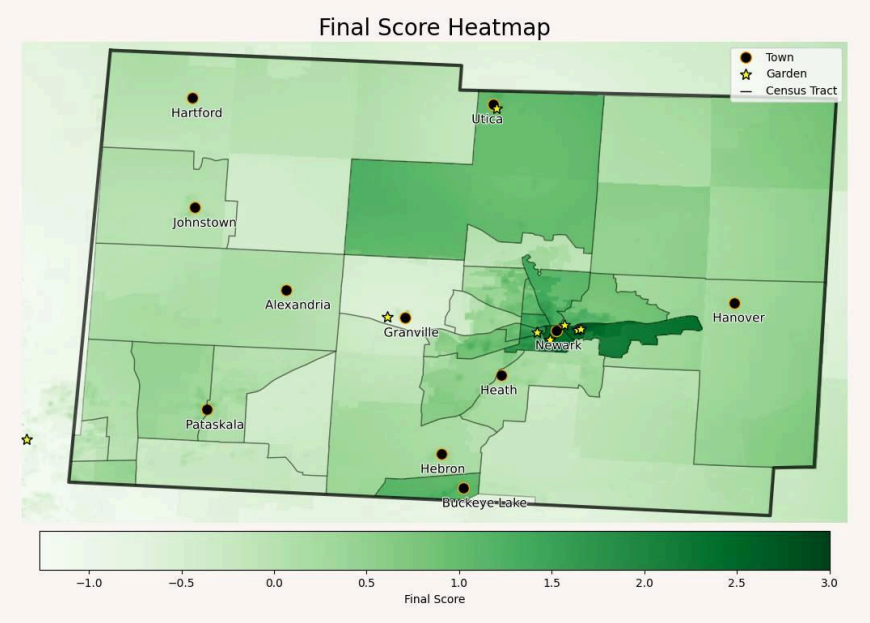

Figure 12: Final score metric heatmap with weighting focused on limited income factors

Sensitivity Formula 2

$$\frac{3}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{2}{20}x_{pov} + \frac{2}{20}x_{SNAP} + \frac{2}{20}x_{ALICE} + \frac{7}{20}x_{garden\ dist} + \frac{3}{20}x_{store\ dist}$$

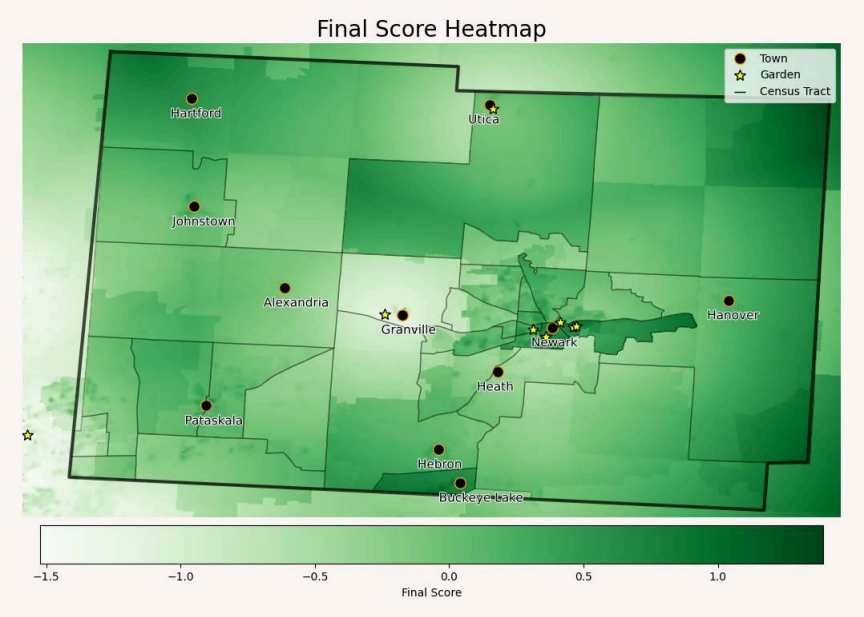

Figure 13: Final score metric heatmap with weighting focused on distance to the nearest garden

Sensitivity Formula 3

$$\frac{2}{20}x_{school} + \frac{6}{20}x_{pop} + \frac{2}{20}x_{pov} + \frac{2}{20}x_{SNAP} + \frac{2}{20}x_{ALICE} + \frac{2}{20}x_{garden\ dist} + \frac{4}{20}x_{store\ dist}$$

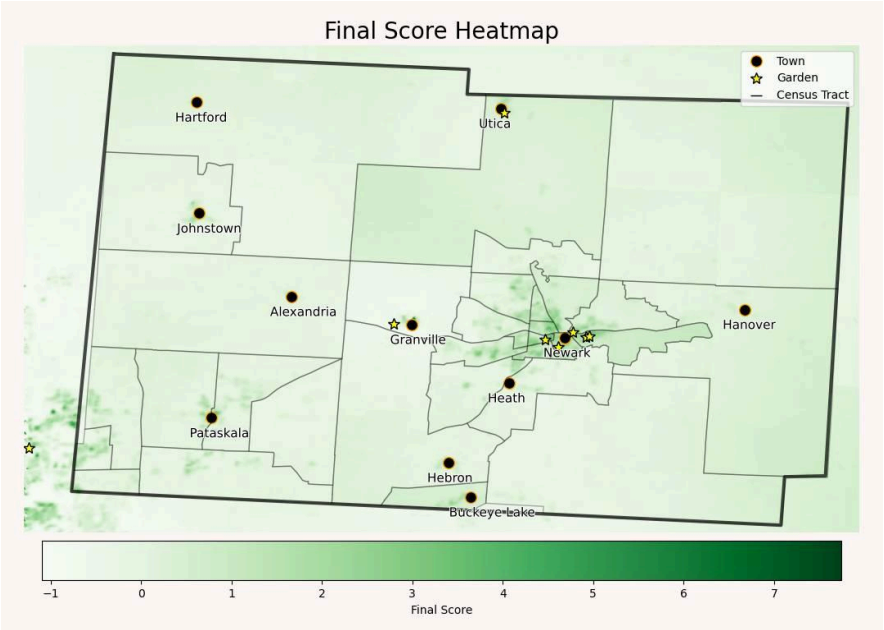

Figure 14: Final score metric heatmap with weighting focused on population density

Sensitivity Formula 4

$$\frac{8}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{2}{20}x_{pov} + \frac{2}{20}x_{SNAP} + \frac{1}{20}x_{ALICE} + \frac{2}{20}x_{garden\ dist} + \frac{3}{20}x_{store\ dist}$$

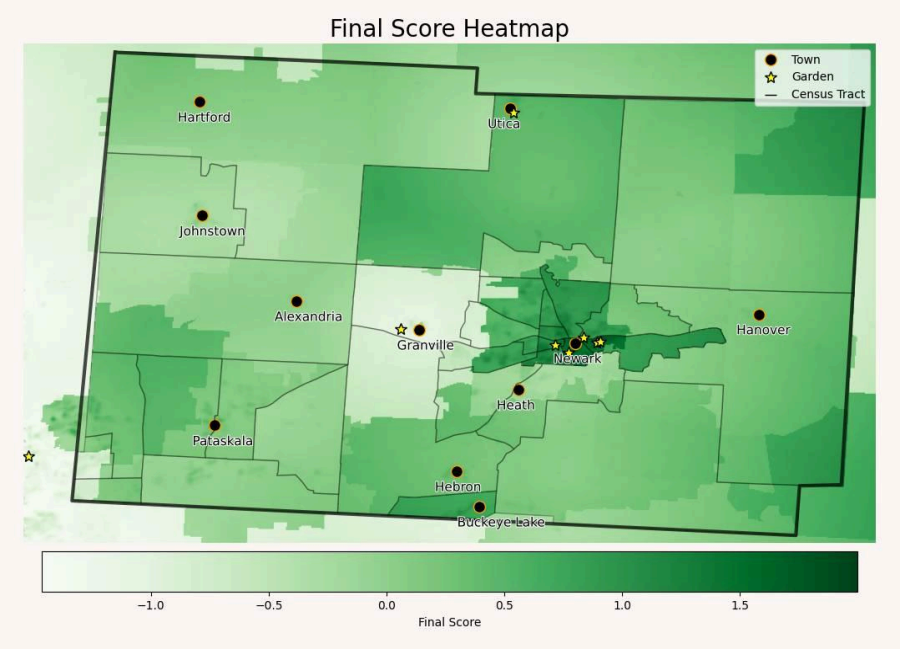

Figure 15: Final score metric heatmap with weighting focused on school district free/reduced lunch rates

Sensitivity Formula 5

$$\frac{2}{20}x_{school} + \frac{2}{20}x_{pop} + \frac{1}{20}x_{pov} + \frac{8}{20}x_{SNAP} + \frac{2}{20}x_{ALICE} + \frac{2}{20}x_{garden\ dist} + \frac{3}{20}x_{store\ dist}$$

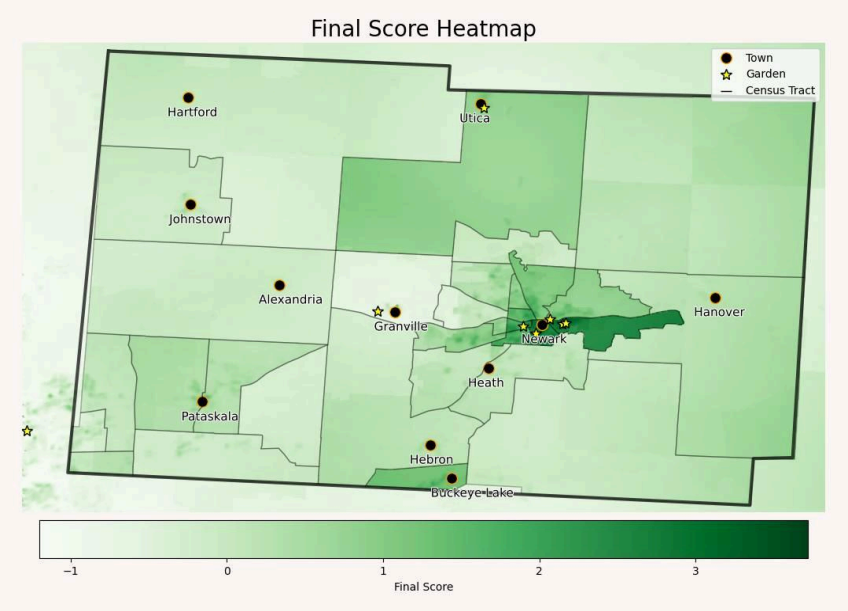

Figure 16: Final score metric heatmap with weighting focused on SNAP usage rates

Sensitivity Formula 6

$$\frac{2}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{5}{20}x_{pov} + \frac{4}{20}x_{SNAP} + \frac{5}{20}x_{ALICE} + \frac{1}{20}x_{garden\ dist} + \frac{2}{20}x_{store\ dist}$$

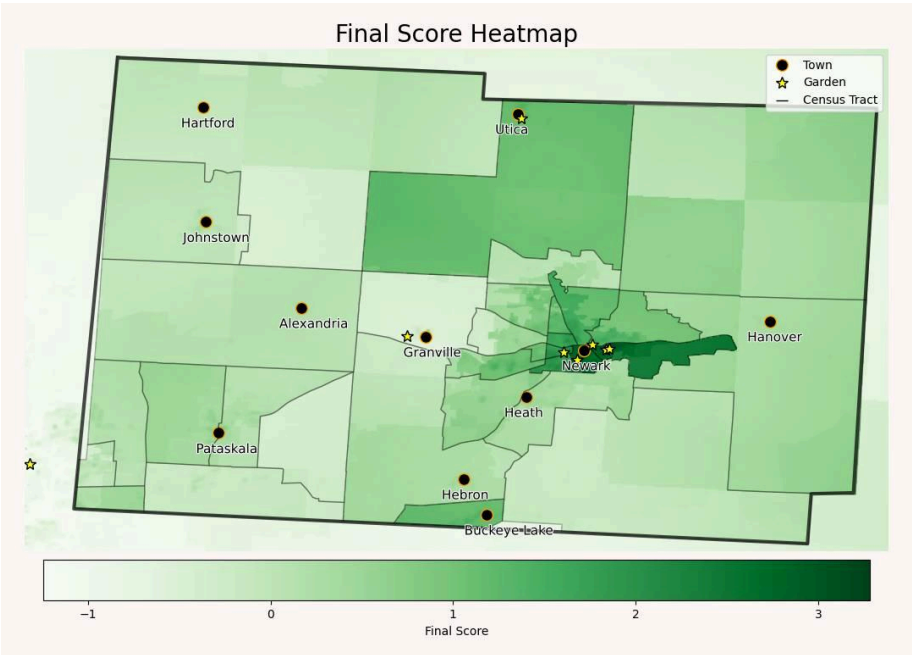

Figure 17: Final score metric heatmap with weighting focused on limited income factors (altered from Figure 12)

Sensitivity Formula 7

$$\frac{5}{20}x_{school} + \frac{1}{20}x_{pop} + \frac{2}{20}x_{pov} + \frac{6}{20}x_{SNAP} + \frac{2}{20}x_{ALICE} + \frac{1}{20}x_{garden\ dist} + \frac{3}{20}x_{store\ dist}$$

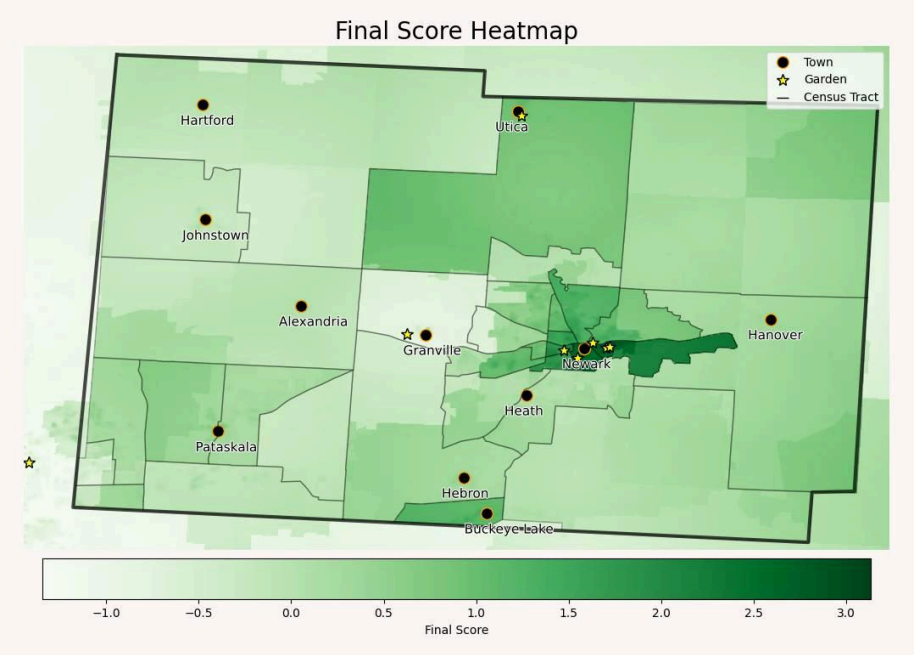

Figure 18: Final score metric heatmap with weighting focused on factors related to meals/meal access

3. Generalizing Statewide

In Figures 19-23, we show examples of the Ohio heatmaps created through the process described in Section 5. The counties selected are the five largest counties in Ohio by population. It is important to note when viewing the maps that the color scale is not consistent across the counties, and each map scale is created independently of other maps. So, even though one map may have an area that is darker compared to an area on a different map, it does not necessarily mean that there is more perceived need there than the lighter area in the other county map. Notice in Figure 21 of Cuyahoga County that the scale goes above 4 when other counties go to around 2.5-3. Given these differences, there will be areas in the other county maps that appear darker than areas of Figure 21 but are lower values. Due to the methods in which we created the heatmaps, the only viable values are those within the county. Perceived need outside of the county lines is inaccurate. All counties are viewable in the Github repository linked here.

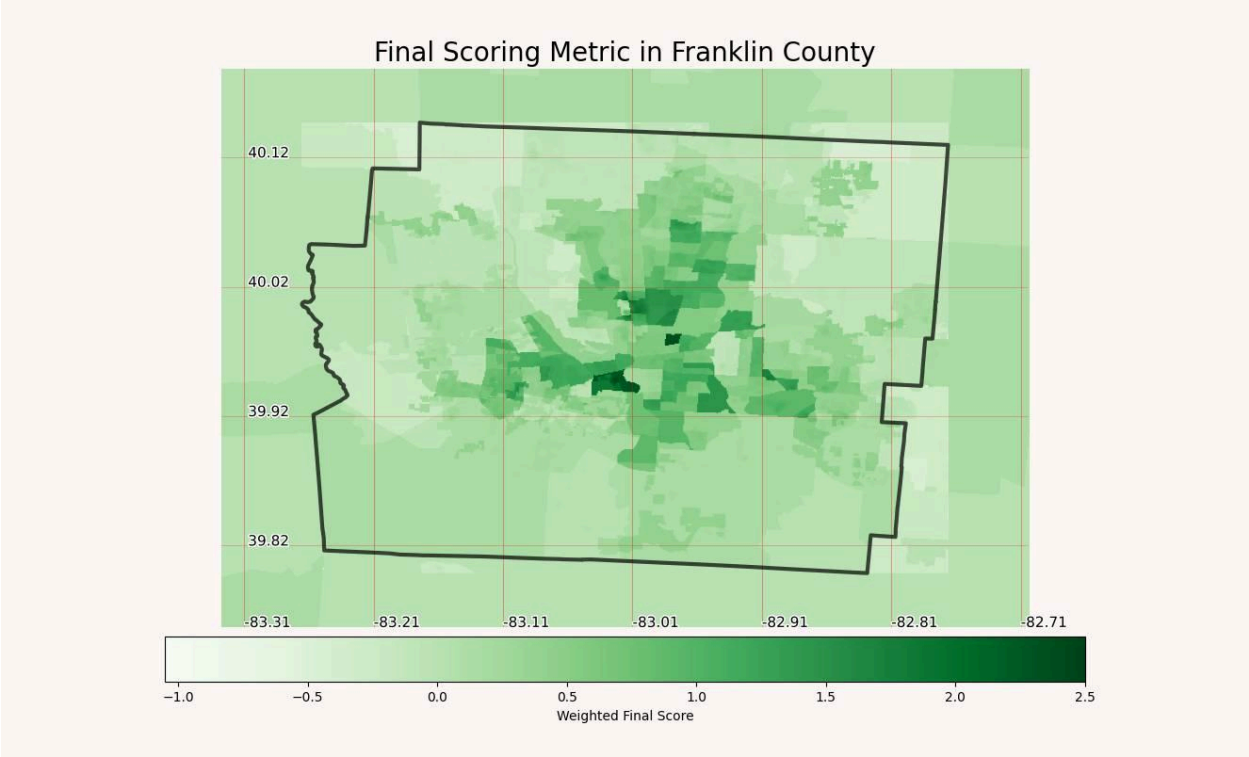

Figure 19: Final scoring metric implemented in Franklin County

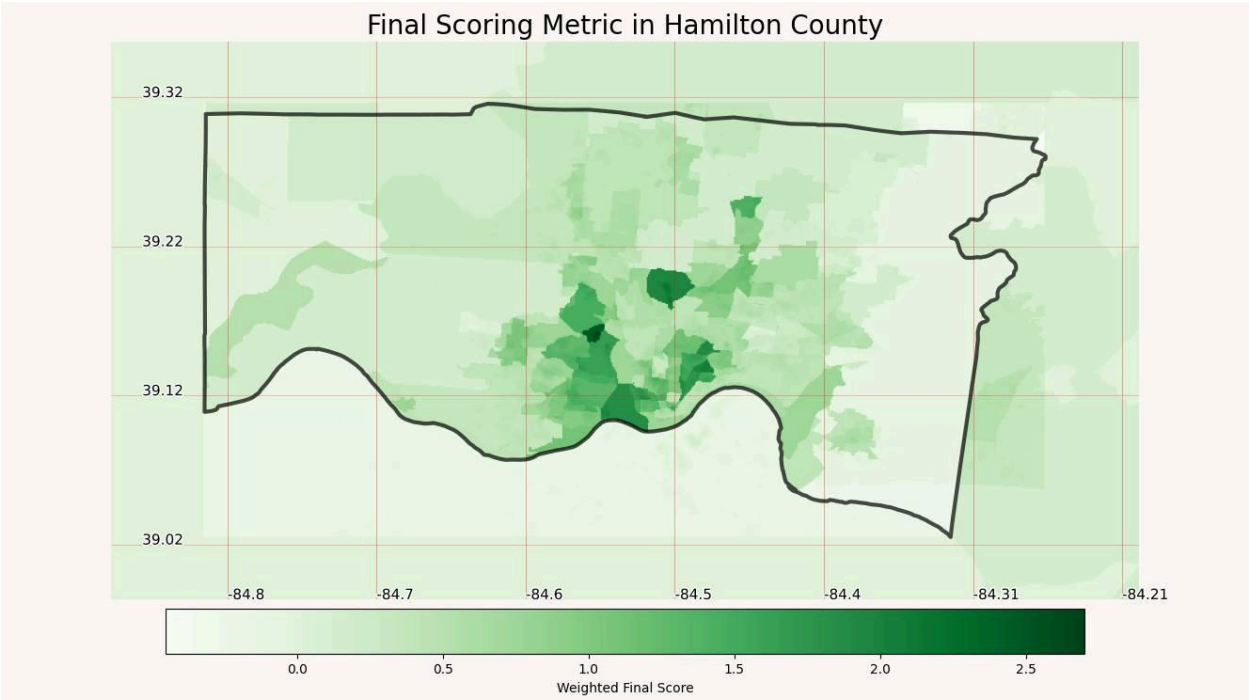

Figure 20: Final scoring metric implemented in Hamilton County

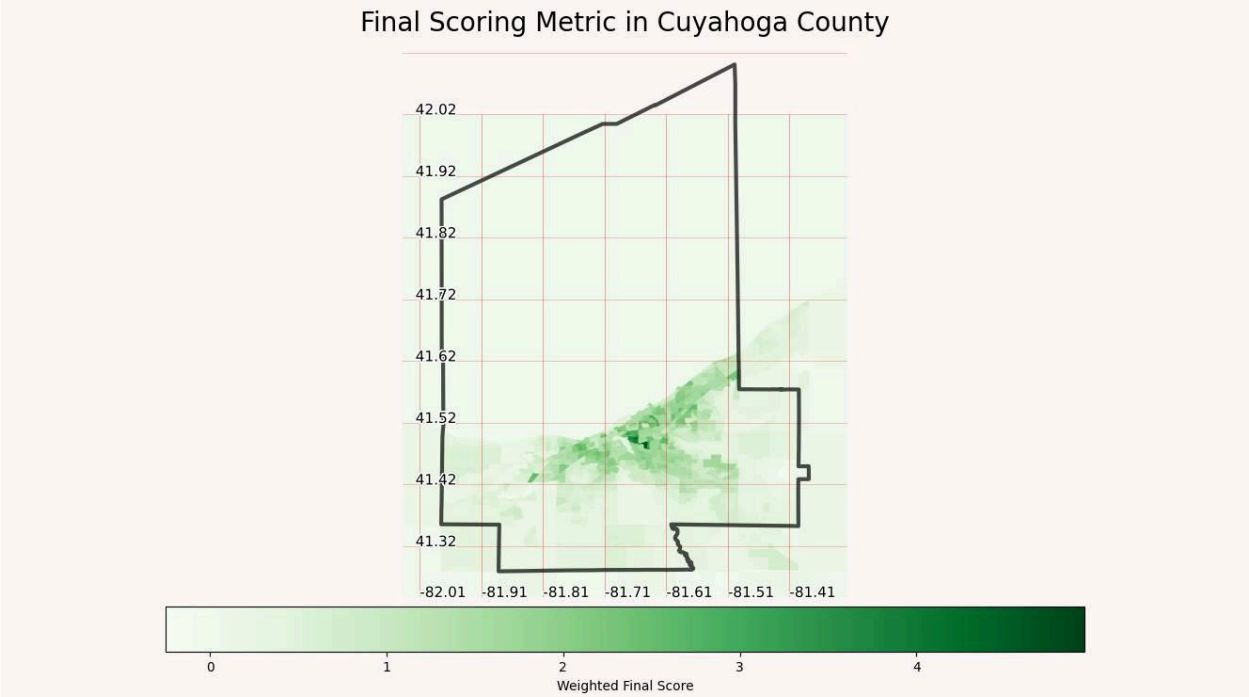

Figure 21: Final scoring metric implemented in Cuyahoga County

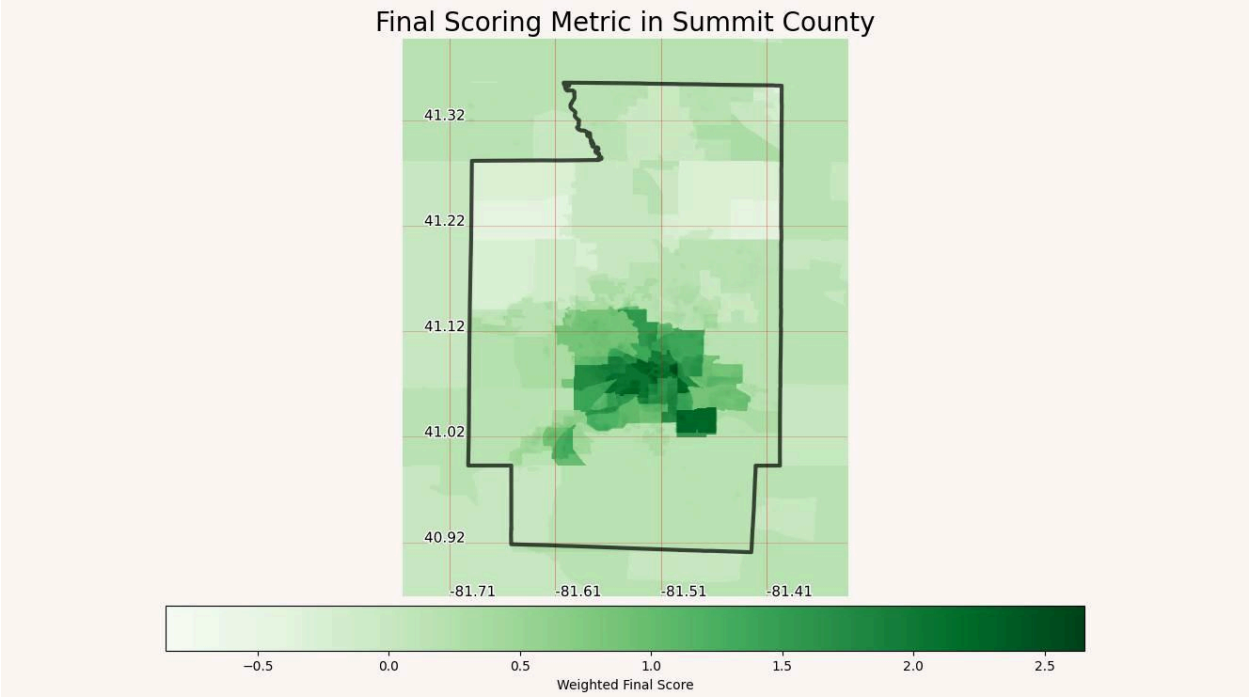

Figure 22: Final scoring metric implemented in Summit County

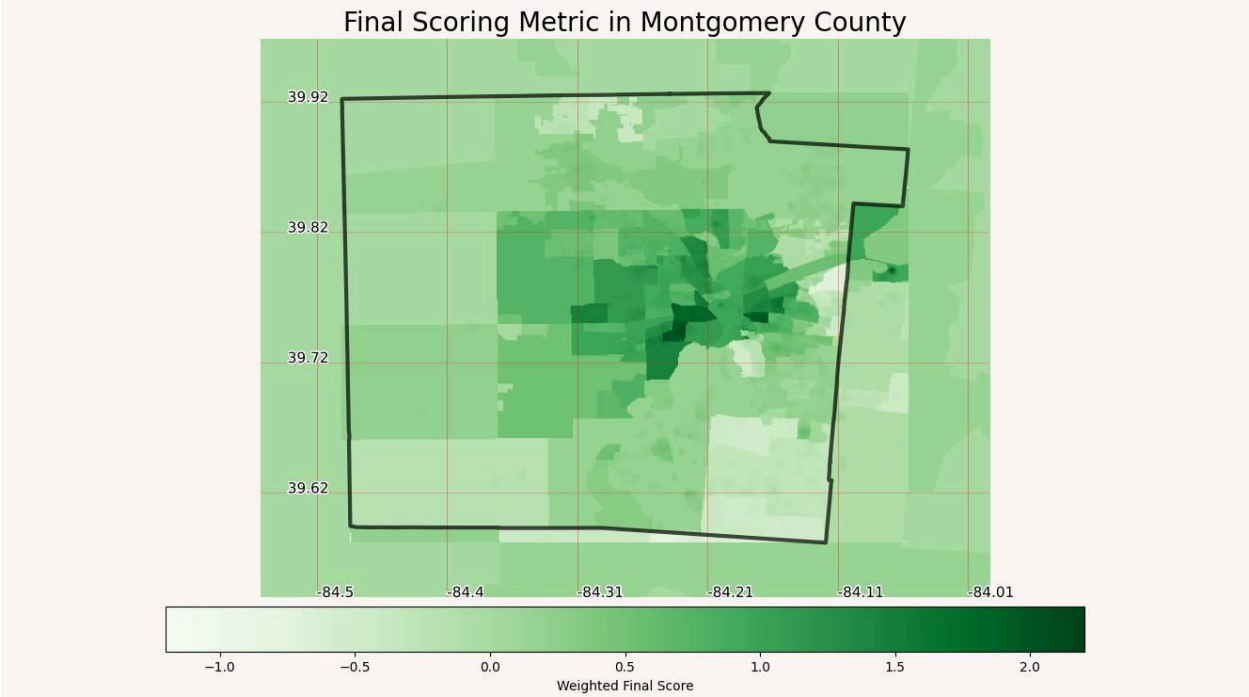

Figure 23: Final scoring metric implemented in Montgomery County

Citations

Corrigan, M. P. (2011). Growing what you eat: Developing community gardens in Baltimore Maryland. *Applied Geography, 31*, 1232-1241. doi:10.1016/j.apgeog.2011.01.017

Dutko, P. (2012). Food Deserts Suffer Persistent Socioeconomic Disadvantage. *Choices, 27*(3), 1-4.

Furness, W. W., & Gallaher C. M. (2018). Food access, food security and community gardens in Rockford IL. *Local Environment, 23*(4), 414-430. https://www.tandfonline.com/doi/full/10.1080/13549839.2018.1426561

GISGeography (2023). Ohio County Map. https://gisgeography.com/ohio-county-map/

Liu, R. H. (2013). Health-Promoting Components of Fruits and Vegetables in the Diet. *Advances in Nutrition, 4*, 384S - 392S. doi:10.3945/an.112.003517.

Rabbitt, M. P., Hales, L. J., Burke, M. P., & Coleman-Jensen, A. (2023). Household food security in the United States in 2022. *USDA Economic Research Service*. https://www.ers.usda.gov/webdocs/publications/107703/err-325_summary.pdf?v=5856.2

National School Breakfast and Lunch Program for Ohio (2024). https://www.benefits.gov/benefit/2010

Ohio Department of Education and Workforce (2023). 2023 Poverty Guidelines for the 48 Contiguous States and The District of Columbia. https://dam.assets.ohio.gov/image/upload/jfs.ohio.gov/owd/WorkforceProf/Docs/FPGLLSIL.pdf

Ohio Department of Education and Workforce (2024). October 2023 (FY2024) Data for Free and Reduced-Price Meals [Data Set].

https://education.ohio.gov/Topics/Student-Supports/Food-and-Nutrition/Resources-and-Tools-for-Food-and-Nutrition/Data-for-Free-and-Reduced-Price-Meal-Eligibility

Ohio Supplemental Nutrition Assistance Program (2024). https://www.benefits.gov/benefit/1588

Schiavina M., Freire S., Carioli A., MacManus K. (2023). GHS-POP R2023A - GHS population grid multitemporal (1975-2030) (2025) [Data Set]. doi:10.2905/2FF68A52-5B5B-4A22-8F40-C41DA8332CFE

Shaw, H. J. (2006). Food Deserts: towards the development of a classification. *Geografiska Annaler, 88* B(2), 231-247.

Teig, E., Amulya, J., Bardwell, L., Buchenau, M., Marshall, J. A., & Litt, J. S. (2009). Collective efficacy in Denver, Colorado: Strengthening neighborhoods and health through community gardens. Health & place, 15(4), 1115–1122. https://doi.org/10.1016/j.healthplace.2009.06.003

Together We Grow Gardens (2024). https://www.togetherwegrowgardens.org/

United For ALICE (2024). 2024 ALICE - Ohio Data Sheet (2022) [Data Set]. https://www.unitedforalice.org/ohio

US Census Bureau (2018). TIGER/Line Shapefile, 2018, state, Ohio, Current Unified School Districts Shapefile State-based [Data Set]. https://catalog.data.gov/dataset/tiger-line-shapefile-2018-state-ohio-current-unified-school-districts-shapefile-state-based

US Census Bureau (2019). TIGER/Line Shapefile, 2019, state, Ohio, Current Census Tract State-based [Data Set]. https://catalog.data.gov/dataset/tiger-line-shapefile-2019-state-ohio-current-census-tract-state-based

US Census Bureau (2019). US Census [Data Set]. https://api.census.gov/data/2019/acs/acs5

US Department of Agriculture (2021). Food Access Research Atlas Data 2019 [Data Set]. https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/#Current%20Version