# Locating Food Infrastructure in Urban Environments

University College London
Center for Advanced Spatial Analytics
MSc in Smart Cities and Urban Analytics
Geographic Information Systems and Science

**Summary**

The following tool can be used to identify potential locations for urban activities that are distributed throughout a city. The tool is applied to the problem of locating food infrastructure in Philadelphia on land currently owned by the City of Philadelphia's Department of Parks and Recreation. The tool will identify land plots for food growing activities, and buildings that could serve as secondary support centers for these primary activities. The Density Based Spatial Clustering Algorithm with Noise (DBSCAN) clustering algorithm is used to create clusters of primary locations, and secondary locations are chosen based on closeness to the centroids of each primary location cluster. An implementation of the the Traveling Sales Person algorithm (TSP) is used to determine an effective route originating at each secondary site that visits all of that site's associated primary sites.

**Background**

The Northeast blackouts of 2003 demonstrated that many urban areas do not store fresh food should supply chains be severed (Belanger and Iarocci, 2008). This, along with rising food prices since the 2007/8 food crisis, has put food supply systems and food infrastructure development on the agenda of major cities (Morgan and Sonnino, 2010; Pothukuchi, 2015).

The deindustrialization of cities in America's Rust Belt has led to large areas of land being left vacant in city centers. Some of these vacant lots could be used to grow fresh food that supports local neighborhoods (Colasanti and Hamm, 2010). Food infrastructure, such as cooled storage and packaging facilities, can greatly extend the amount of time each year that fresh food can be made available from local sources (Colasanti and Hamm, 2010). Increasing the availability of fresh food is a crucial issue, as the existence of food deserts, areas where access to affordable fresh food is limited, in cities has been widely acknowledged (Clarke et al., 2004; Eckert and Shetty, 2011; Gittelsohn et al., 2008; Powell et al., 2007; Walker et al., 2010; Wrigley et al., 2004; Zenk et al., 2011).

**Data and Tools Used**

The data used to model the tool is drawn from the City of Philadelphia's Department of Parks and Recreation (PPR) Assets inventory, freely available from the Open Data Philly online portal. The PPR Asset inventory shapefile catalogs properties designated for use as programming and inventory spaces, and contains three types of features: land, buildings, and structures. Each feature has a plot size in acres. Results are plotted on Philadelphia neighborhood boundaries which also available from Open Data Philly (Opendataphilly.org). The rgdal, sp, SpatialTools, dbscan, and TSP libraries are imported and used in the analysis.

**Scientific Basis and Description of Analysis**

We begin by importing all of the libraries that will be used, and loading the PPR_Assets and Neighborhoods shapefiles. Next, the user has six parameters to set. These are the lower and upper limits on land acreage for land plots to be considered for agricultural use, the lower limit on site acreage for a site to be considered for designation as a service center, two parameters for the dbscan algorithm to decide how to cluster the land plots, and the name of the asset types to use in the analysis.

In the example analysis, we choose a lower and upper limit on land plot size of 1 and 1.5 acres, respectively; a minimum building size of 1 acre; the minimum number of points necessary to be in a point's neighborhood to include it in a cluster (minPts) to be 1; the minimum distance between points to be considered in the same neighborhood (epsilon) to be 0.04 decimal degrees; and to use "Land" assets for agricultural uses and "Building" assets for service centers.

We create a bigLand data frame by subsetting the PPR_Assets for the "Land" features that are between 1 and 1.5 acres. Next, we calculate the centroids of the plot polygons. These centroid coordinates are used by the dbscan algorithm to determine the number of clusters in the data.

The dbscan algorithm begins with a random point, creates a circle of radius epsilon around that point, and counts the number of other points inside the circle. If the number of points is above the cutoff minPts, then these points are considered to be in a cluster together. The algorithm will then move to these other points and apply the same algorithm, creating a circle of radius epsilon and counting the number of other points that fall within the circle. Any new points that have not yet been assigned a cluster will be added to the current cluster. When there are no more additions that can be made to the current cluster, the algorithm will pick another random point and repeat the process until all points have been assigned a cluster. All points that have no neighbors in a circle of radius epsilon will be assigned to a cluster of 0. To avoid these being considered part of the same cluster, these points are each assigned their own cluster number.

Now the points have been clustered, and they are ready to be assigned to a servicing site. We create a bigBuild data frame by subsetting the PPR_Assets for the "Building" features that are larger than 1 acre. These building polygons are plotted along with the land feature polygons and the land feature centroids over a map of Philadelphia neighborhoods to provide context. The final component of the analysis involves the assignment of building sites to land plot clusters, and the calculation of efficient routes for the servicing of the land plots.

For each of the clusters created by the dbscan algorithm, the building closest to the centroid of that cluster's land plots is chosen to be the service center. The TSP algorithm is then used to calculate an efficient order to visit all of the land plots from the service center that minimizes the total travel distance. The order derived from the TSP algorithm is used to display a series of straight line paths to indicate the service route.

**Potential Gardens, Service Sites, and Service Routes**

+ = Garden Site, o = Service Site
Properties Drawn from PPR Assets in Philadelphia

## Discussion

This tool can be used to identify sites for developing food infrastructure in urban environments, as demonstrated above. Given a set of land and facility assets, and parameters for what makes a site viable, the tool is able to create proximity based clusters of land assets and assign them to the nearest available service facility. It is then capable of displaying an efficient route for how the land assets could be serviced. This would be useful for the distribution of materials such as seeds, fertilizer, raised garden beds or the materials for constructing them, or tools used to prepare land for planting; or for the collection of materials such as tools once they are ready to be returned, or crop yields when they are ready to be harvested and processed.

This tool could be applied to identify locations for any urban project that requires reservation of space for primary use and support from a secondary service site, such as supplying live music equipment to areas throughout the city where festivities will be held.

**Limitations and Further Work**

The analysis is limited in several crucial ways. First, the distances used to group vacant lots with each other and to determine the optimum routes from the secondary sites to visit all associated primary sites is based on the euclidian distance between the two points. It would be more realistic to construct these distance metrics according to the road network. The recommended routes would also be more useful if they were constrained to the road network.

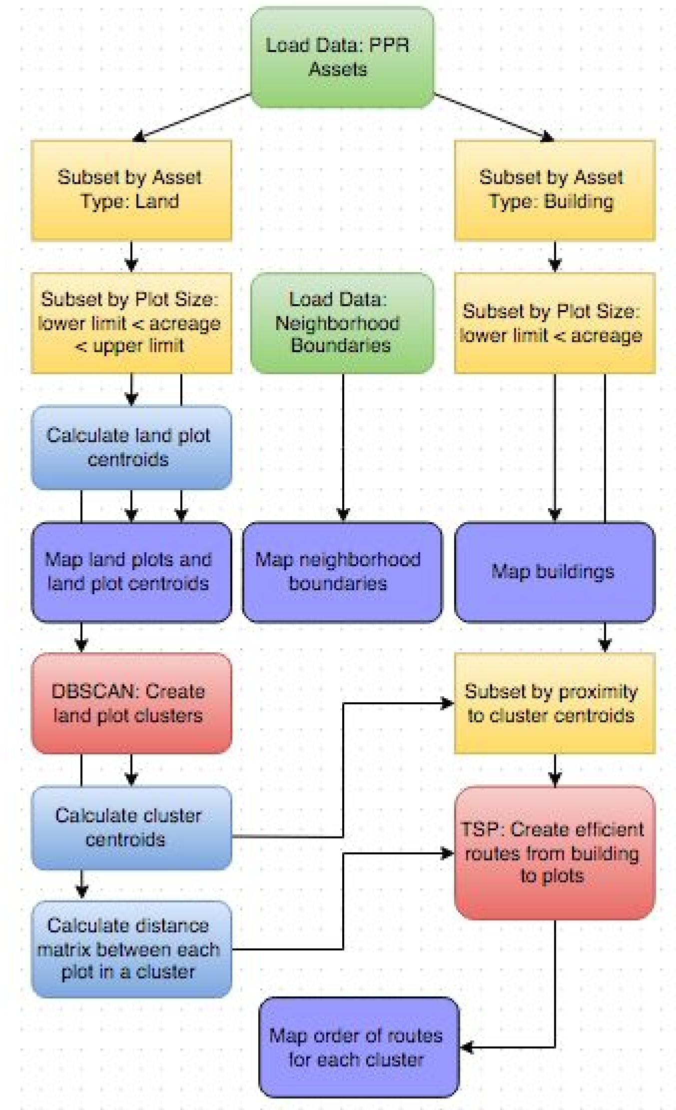
The PPR assets used to identify potential locations may not be realistic options, as the PPR may not be willing to convert these available facilities to full-time food infrastructure use. Further research would be necessary to identify which buildings are either vacant or could feasibly be converted from their current use to serving as food infrastructure.

Zoning ordinances pose another substantial barrier to converting urban land into food infrastructure. Additional research would be necessary to determine which zoning codes allow for urban agriculture and food processing and which do not. This research could be used as a basis for recommending changes to the zoning code that would allow for the better utilization of land and buildings for local food production.

The analysis could be extended to include more factors in deciding which lots should be cultivated as urban agriculture projects such as the quality of the soil, accessibility of the plot via public transportation, demographic characteristics of nearby neighborhoods, shape of the plot, proximity to critical infrastructure or environmentally sensitive areas, and proximity to existing healthy food infrastructure such as farmers markets or corner stores that are willing to stock fresh food from local sources.

The clusters and routes calculated by dbscan and TSP algorithms are not necessarily the most efficient, as can be noted by the unequal numbers of land plots assigned to the clusters and some seemingly circuitous routes. This is partly due to the design of the dbscan algorithm, which groups points by proximity without considering the minimization of route distance that the TSP algorithm will later perform. Further work should mix these two approaches and generate clusters based on the minimum route distance of all service routes, and which respect the carrying capacity of vehicles that will either be delivering or retrieving materials from the sites.

**Appendix:**




**Documentation**

The shapefiles PPR_Assets and Neighborhood Boundaries may be replaced by any two shapefiles that have the same projection system. The replacement for PPR_Assets must contain a Spatial Polygons Data Frame, with data fields labeled TYPE to differentiate between primary and secondary activity sites, and ACREAGE to indicate the total area that both type of sites occupy.

The definition of epsilon for the DBSCAN algorithm must be made with reference to the coordinate system that is used in the shapefiles. In this case, it is measured in decimal degrees. If epsilon is too large then all of the land sites will be grouped in one cluster. If epsilon is too small then many land sites will be isolated in their own cluster.

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