# Optimal Location for Bike Sharing Stations in Downtown Kalamazoo

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## Abstract

At present, emphasis is on increasing physical activities and expanding access to goods and services through non-motorized modes in order to enhance safety, social sustainability in transportation equity, environmental justice, and public health. Hence, there is an interest in developing bike sharing systems to encourage non-motorized activities in cities. This study focuses on developing a bike sharing system for city of Kalamazoo. One key parameter for a successful system is to identify optimum locations for bike sharing stations. This poster presents implementation of location-allocation models and spatial analysis tools to determine the most suitable locations for bike sharing stations within the city. Locations identified from these models can be used by city planners and stakeholders as supplementary information for planning a new bike sharing system.

## Bike Sharing System

Bike sharing is a system designed for point-to-point short trips using a for-rent fleet of bicycles strategically located at docking stations throughout a well-defined project area and within reasonable distance from each other.

Prior to launching a bike sharing program, at least the following key points need to be considered as part of planning:

a. Identify dense areas such as areas with high population, job rates, commercial/retail activity, and pedestrian activities. Also, areas that are located at close proximities to colleges or universities, touristic attractions, recreational facilities, and hospitals need to be included.
b. Identify number of short trips within and between these dense areas.
c. Identify available bicycle infrastructure (bike lanes, shared-use paths, etc.)
d. Identify connectivity with other modes of transport
e. Identify social equity such as low income housing, percent living in poverty, and percent of non-English speakers.
f. Identify areas with slope no greater than 4%

## Methodology

### Defining initial service area

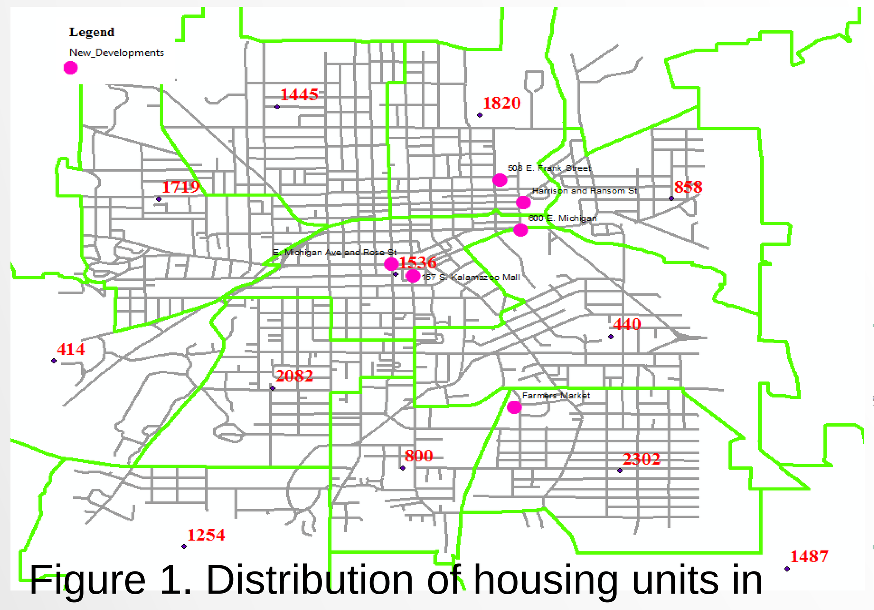

Figure 1. Distribution of housing units in downtown Kalamazoo

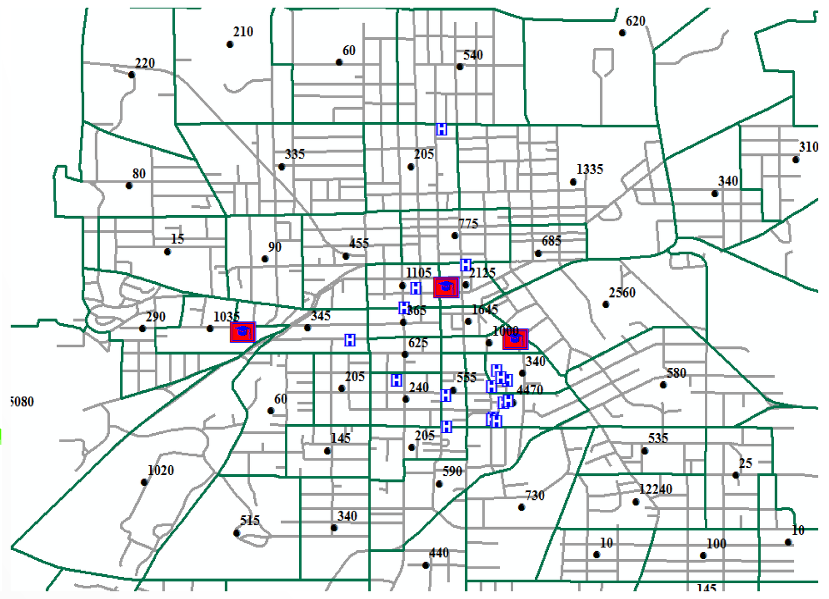

Figure 2. Employment

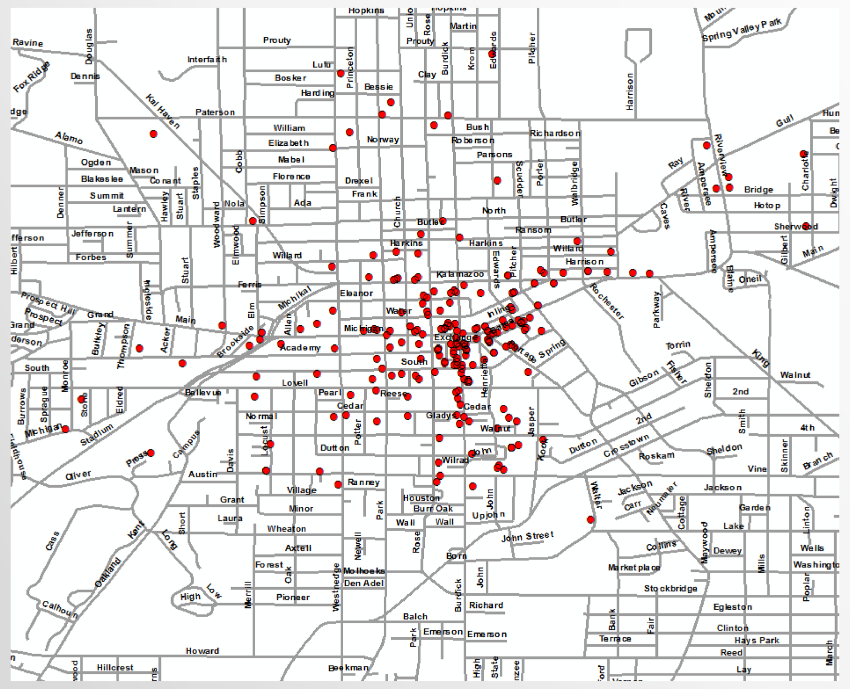

Figure 3. Location of interest

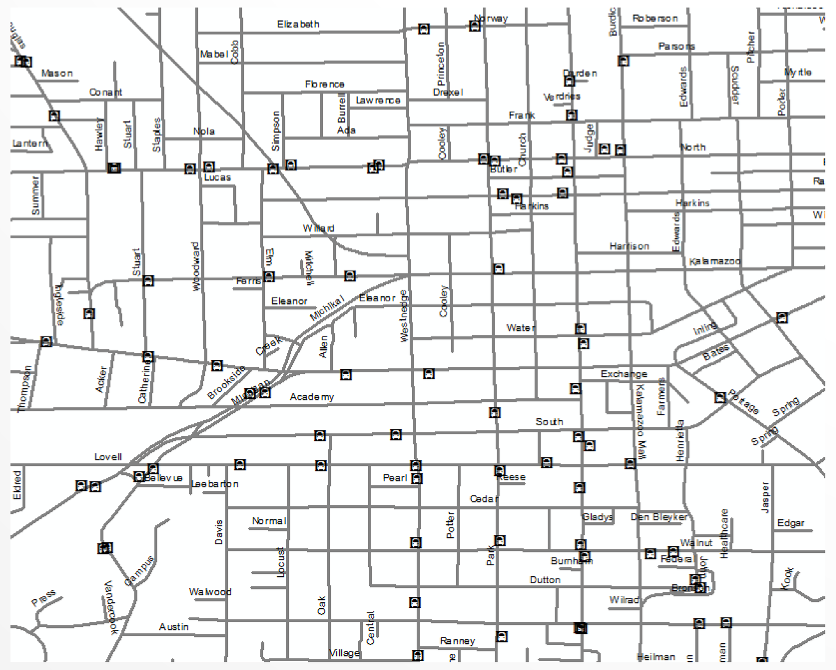

Figure 4. Transit intermodality

## Methodology

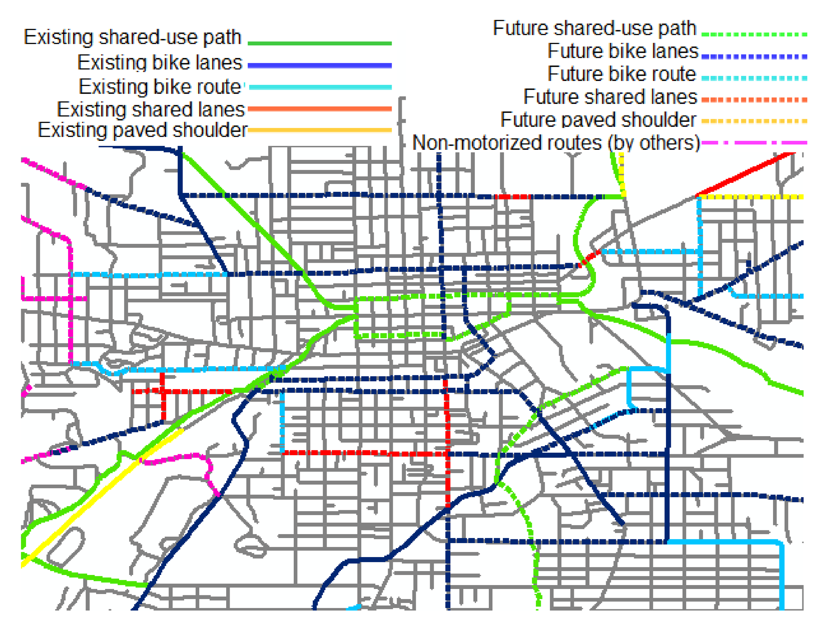


Figure 5. Non-motorized facilities

Figure 6. Topography

### Minimum size of the program

A minimum of 10 stations is recommended to provide an effective mix of trips' origins and destinations and justification of maintenance cost. Thirty (30) candidate stations are selected and optimized to identify the number of stations for this system. These candidate stations were located throughout downtown Kalamazoo area based on the location of the demand, available non-motorized facilities, possibility of intermodality, and topography).

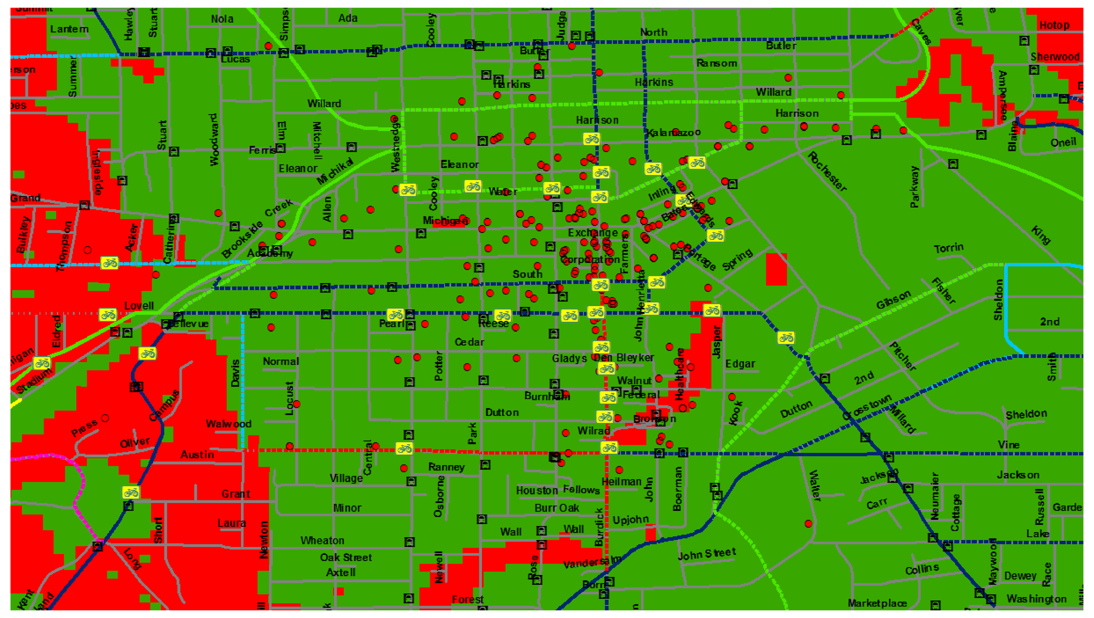

Figure 7. Bike sharing candidates stations

### Location – Allocation Models

Location-allocation models are used to identify the optimal location for new facilities such as fire stations, schools, hospitals, etc. In this study, *maximize coverage* and *minimize facilities* models are used to identify optimal locations of bike sharing stations from a group of candidates. The models main constraint is the desired walking distance defined as ¼ mile. The following are the location – allocation models used in this study:

**Maximize coverage model**

$$Maximize \sum_{i \in I} a_i y_i \quad (1)$$

subjected to the following constraints:

$$\sum_{j \in N_i} x_j \geq y_i \quad (2) \quad for\ all\ i \in I$$

$$\sum_{j \in J} x_j = P \quad (3)$$

**Minimize facilities model**

$$Minimize \sum_{j \in J} x_j \quad (4)$$

subjected to the following constraints:

$$\sum_{j \in N_i} x_j \geq 1 \quad (5) \quad for\ all\ i \in I$$

$$x_j = \begin{cases} 1\ if\ node\ j\ is\ a\ facility\ site \\ 0\ otherwise \end{cases} \quad for\ all\ j \in J$$

Where,
I = set of demand locations,
J = set of candidate stations,
P = number of stations to be allocated,
$x_j$ = 1 if station allocated at j, 0 otherwise,
$y_i$ = 1 if demand is covered at i, 0 otherwise,
S = desired walking distance,
$d_{ij}$ = distance from demand node to candidate facility,
$N_i = \{j \in J | d_{ij} \leq S\}$ set of candidates which can cover demand i,
$a_i$ = demand at node i.

## Outcome

The maximize coverage model allocated 190 *Location of Interest* to 25 stations (Figure 8). The minimize facilities model allocated 190 *Location of Interest* to 11 stations (Figure 9).

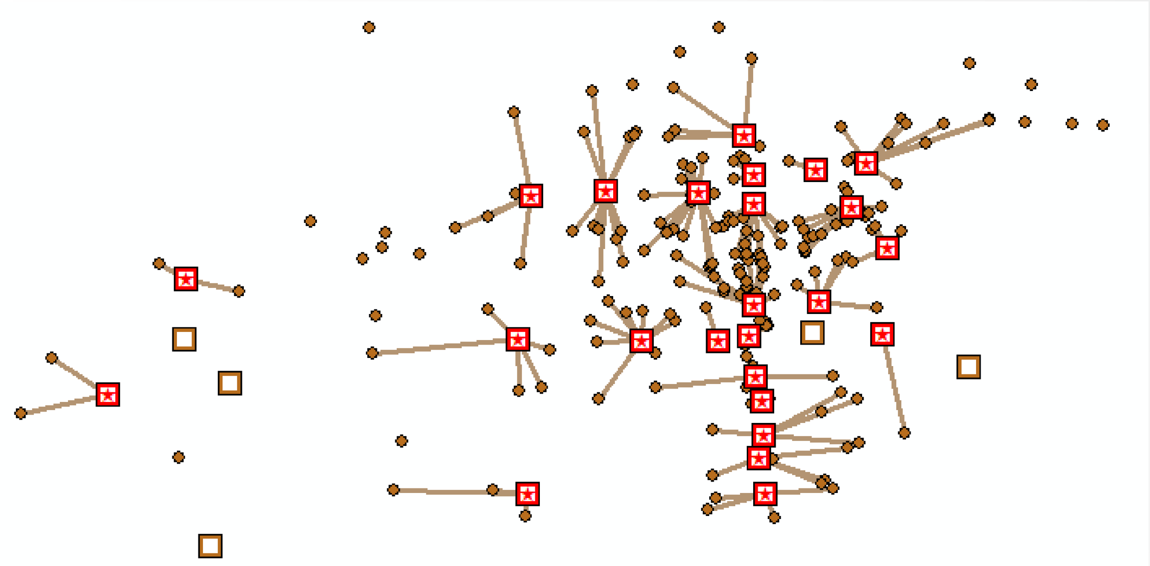

Figure 8. Maximize coverage for *Location of Interest Demand*

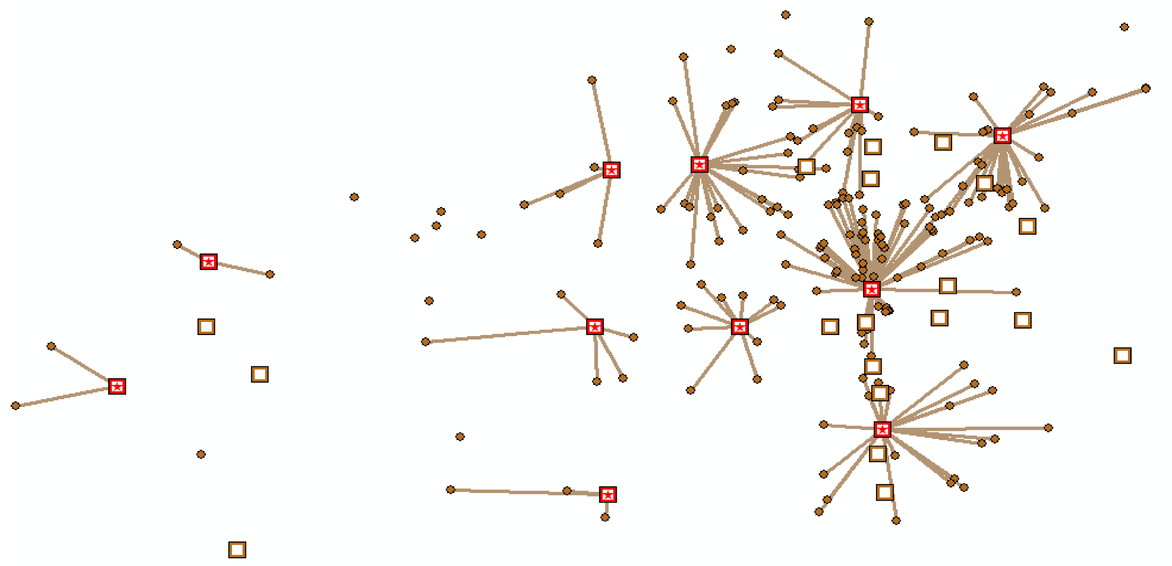

Figure 9. Minimize facilities for *Location of Interest Demand*

The following are the conclusions derived from this study:

- The size of the system can range from 11 – 25 stations based on available budget (Figure 10 & 11).
- The use of less stations will require more bicycles.
- The models main constraint is the desired walking distance.
- When planning, the models can be used to define the upper and lower bound of optimum number stations for the system.

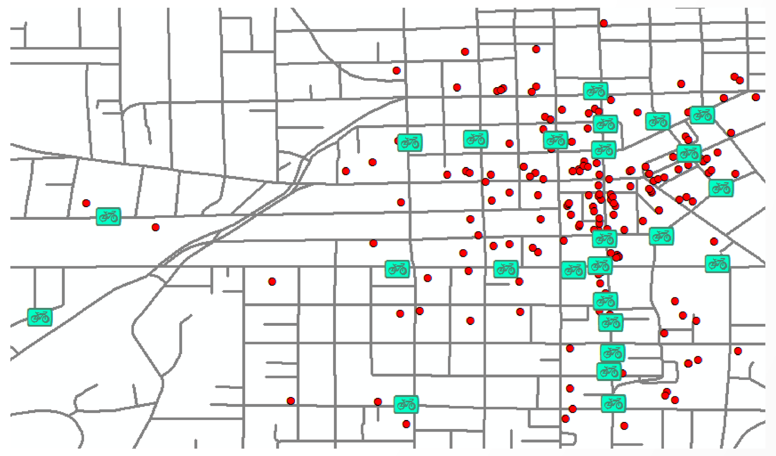

Figure 10. Optimal bike share station based on *maximize coverage model*

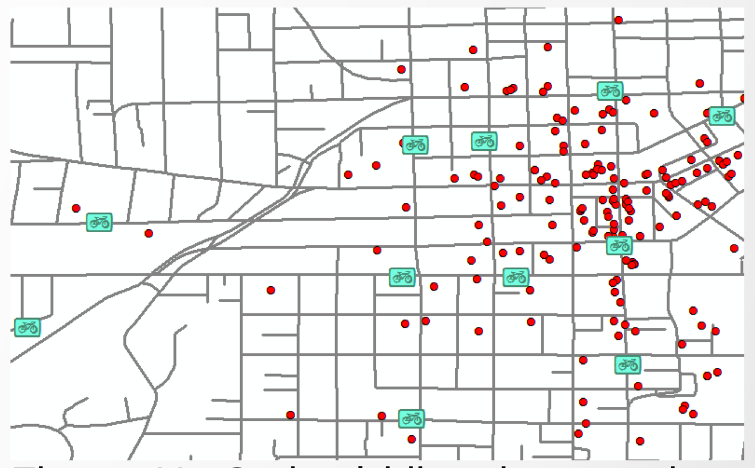

Figure 11. Optimal bike share station based on *minimize facilities model*

## Future tasks

1. Evaluate the possibility of implementation.
2. The study did not include data representing social equity such as low income housing, percent living in poverty, and percent of non-English speakers. When planning is conducted for system expansion the above parameters to be included
3. Evaluating demand to determine number of bicycles per station
4. Business model evaluation
5. Conducting a survey to evaluate acceptance by public

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