Jurnal Perencanaan Wilayah dan Kota
vol. 16, no. 1, hal. 17-28, Bulan Maret Tahun 2019

INCORPORATING PUBLIC INPUT WITH GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR BICYCLE STRATEGIC PLANNING

A Case Study of Grand Prairie, Texas

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ABSTRACT

Desire for active transportation is on the rise. However, the need for data and ways to incorporate public input in bicycle strategic planning are challenges faced by local governments with inadequate resources and time. The study aims to investigate mechanisms of input data by public which can included in the strategic planning of bicycles. Here, case study adopted a mix-methods approach to gather public input data in order to understand residents' cycling patterns, needs, perceived barriers to cycling and preference for cycling facilities. The mix-methods approach included an intercept survey and several small group meetings. The non-probability sample design was used in this particular case because of the quick turn-around requirement and exploratory nature of the study with no financial resource. This paper presents a case study of bicycle strategic planning in the City of Grand Prairie, Texas. It illustrates how local governments can engage the public in bicycle planning through a public input process and use of GIS. The approach is useful for local governments elsewhere to meet their immediate needs for data and to promote active transportation with limited resources and time.

Keywords*: bicycle strategic planning, public input, intercept survey, small group, GIS*

INTRODUCTION

As cities and regions are embracing sustainable transportation and healthy communities, active transportation, namely non-motorized travel, is gaining momentum (ABW, 2014). Funding opportunities for bicycle and pedestrian projects have increased. Numbers of cycling and walking trips are on the rise (FHWA, 2010; ABW, 2014). Despite the encouraging news, share of pedestrian and bicycle travel remains small. Transportation planners and **decision** makers are in need of data and research to understand bicycle/pedestrian travel behavior and demands in order to better plan transportation facilities (Kuzmyak & Dill, 2012). The need for data and ways to incorporate public input in pedestrian and bicycle planning is more profound at the local level as cities are facing the challenge with inadequate resources and time.

This paper presents a case study of strategic planning of bicycle infrastructure with limited resource and time. It focuses on a low-cost, mixed-methods approach including an intercept survey and small group meetings to gather public input on bicycle usage, barriers, and preference, as well as the use of Geographic Information Systems (GIS) to incorporate this locally context-sensitive information for bicycle strategic planning and assess equity impact of planning options. While the non-random sampling techniques for data collection may not be as rigorous as formal random sampling techniques, they can, with strategic selections of survey locations and targeted group meetings, be used to provide reasonably reliable information for bicycle planning (Troped et al., 2009; Sperry et al., 2010). The approach can also gather locally context-sensitive verbal information that may not be picked up by a formal structured survey or counts by technological solutions. Moreover, while studies have used GIS with secondary quantitative data for bicycle demand forecasting or cycling network optimization analyses (see, e.g., Rybarczyk and Wu, 2010; Larsen et al., 2013; Rybarczyk, 2014), few studies have demonstrated the use of GIS to incorporate information generated from public input into strategic planning of bicycle facilities. Lessons from this case study can be used by local governments to meet their immediate needs for data and to promote active transportation with limited resources and time.

In the following, trends in bicycle and pedestrian travel and relevant studies are reviewed. A brief description of Grand Prairie, Texas, and the data collection approach used in this study are provided. Findings of bicycle usage, barriers, and preference are presented. Potential bicycle plan scenarios based on the public input are outlined and the spatial impacts of the scenarios are explored in the subsequent sections. The paper is concluded with a summary of the study and discussion for future studies.

BICYCLE AND PEDESTRIAN TRAVEL IN THE U.S.

Desire for active transportation is on the rise in cities and regions across the United States. Federal funding for pedestrian and bicycle projects has increased in recent years. According to the Federal Highway Administration (FHWA), federal-aid funding for pedestrian and bicycle projects had increased from about $22.9 million in 1992 to near $859.8 million in 2016 (FHWA, 2017). While several federal programs with dedicated funding for bicycle and pedestrian projects have been consolidated in recent transportation legislations, there is an array of programs to support active transportation projects at the federal and state levels (ABW, 2014; 2016). The increase in desire for active transport is evidenced in states and cities, as 68% of the 50 states and 75% of the 52 cities surveyed by the Alliance for Biking & Walking (ABW) have adopted goals to increase bicycling and walking (ABW, 2014).

Walking and cycling trips have also increased. These trips, as reported in the National Household Travel Survey (NHTS), had increased by 25% between 2001 and 2009 (FHWA, 2010). However, despite the significant increase in total number of walking and cycling, the share of trips by walking and cycling only increased modestly, from 8.6% in 2001 to 10.5% in 2009 for walking trips and only from 0.9% to 1% for cycling trips in the same period. Similarly, the change in walking and cycling per capita remains small during the same period. The increase in number of daily walking trips per capita was about 0.05 while the increase in number for cycling was only 0.01. The changes in travel distance and time for both walking and cycling on average are also small (Pucher, et al., 2011; ABW, 2014). These trends have called for research to better understand factors contributing to active travel decisions, as well as practices and evidence-based innovations for data collection and promotion of active travel (Kuzmyak & Dill, 2012; Kuzmyak, et al., 2014).

BICYCLE AND PEDESTRIAN STUDIES

A number of efforts have been completed or are underway to address these gaps in data collection and study of active travel decisions. For instance, in addition to the NHTS, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) sponsored the National Survey of Bicyclist and Pedestrian Attitudes and Behavior (NSBPAB) in 2012, and findings on bicycle and pedestrian activities and attitudes of persons aged 16 years and older living in the United States were reported (Schroeder and Wilbur, 2013). While the NHTS, NSBPAB, and other existing nationwide datasets continue to be significant sources of data for research and planning, the use of such data for local planning, especially for small size cities or communities within a city where planning actions are often taken place, is likely to be limited due to small sample size and data with high degree of geographic aggregation level in those major datasets.

Several other significant studies have attempted to address gaps in data collection, demand modeling, and guidelines for bike and pedestrian facility design. With a goal to lower the cost of data collection for corridor planning, Forsyth et al (2010) proposed a tool, named Pedestrian and Bicycle Survey (PABS), for collecting pedestrian and bicycle data. Like other scientific surveys, the tool relies on travel diary and mail survey method. Aultman-Hall et al. (2012) suggested technologic-based solutions to improve pedestrian and bicycle volume counts. However, they also recognized the many challenges surrounding the usage of counting technologies and called for research on, among others, development of guidelines for data collection and management.

The NCHRP project #07-19, sponsored by the Transportation Research Board (TRB), assessed current and potential data collection techniques and produced a guidebook to aid the collection of data. The project focuses on the testing and evaluation of various automated count technologies for pedestrian and bicycle volume data collection. The technologies are assessed mainly in terms of volume counting accuracy. Other criteria include ease of implementation and data usage, as well as cost, labor and software requirements among others. The testing results suggest that automated technologies vary in terms of accuracy and users are encouraged to select particular products based on their special circumstance (Ryus, et al., 2014). In addition to these recognized challenges, technologic-based solutions, like many typical travel dairy/structured survey methods, are also limited in their ability to collect locally context-sensitive data, such as the needs for, barriers of, and perceptions towards bicycle and pedestrian travel.

Efforts have also been made in recent years to address the need for research to better understand factors contributing to active travel decisions and travel demand modeling. For instance, the TRB commissioned a project, NCHRP project #8-78, to produce a guidebook for quantifying and forecasting bicycle and pedestrian travel. The goal of the project is to provide consistent, “robust methods to accurately estimate bicycle and walk activities to support design and prioritization of pedestrian and bicycle facilities and systems” (Kuzmyak, et al., 2014). Based on the existing literature on travel demand studies and interviews with practitioners, the project identifies an array of factors related to bicycling and walking and provides a number of analytical tools and models for estimating bicycling and walking activities. Many models follow a classic, scientific, quantitative paradigm such as the four-step modeling process for travel demand estimation. While there is no question about their contributions to the field of study on forecasting demands for bicycling and walking activities, these models are highly sophisticated. They require considerable quantitative data and technical expertise to perform the analysis. These requirements, however, are often the challenges faced by local governments due to limitations in resource and expertise. In addition, local governments are required to engage the public in the planning process and incorporate public input in planning decisions. The ability of quantitative-paradigm-based models to incorporate qualitative public input is often limited.

GIS is a powerful tool for planning as it enables spatial and temporal analysis and visualization. As GIS becomes more user friendly, the use of GIS for bicycle planning is on the rise. However, most studies use GIS for generating quantitative data for bicycle demand modeling or cycling network optimization based on secondary quantitative data from the lens of experts and/or for visualization purpose. Fewer studies incorporate verbal/textual public input into strategic bicycle planning. For example, Tilahun et al. (2007) used GIS to illustrate locations of bicycle facilities in a stated-preference survey. Using data from the Wisconsin Bicycle Federation U.S. Census Bureau, Milwaukee County, and the City of Milwaukee, Rybarczyk & Wu (2010) were able to derive a number of indices at the network and neighborhood levels and apply the data to optimize bicycle facilities. Larson et al. (2013) applied data from an online survey of bicyclists, a regional O-D survey, and auto insurance to GIS to determine the optimal locations for a new bicycle facility in Montreal, Canada. GIS was used to estimate missing bicycle counts and to identify buffer zones from the existing transportation facilities in a simulation study by Rybarczyk (2014). Several other studies, such as Arampatzis et al. (2004), Papinski and Scott (2011), Neutens et al. (2012), and Tsenkova and Mahalek (2014) also used GIS for automobile route choice modeling, bus service analysis, and assessing the effect of bicycle-transit integration.

A few studies incorporate verbal/textual data into GIS for bicycle planning. Through focus group discussions among cyclists who arrive at recreational facilities with all-terrain vehicles (ATVs), Snyder et al. (2008) identified “the meanings and perceptions associated with optimal ATV riders and trails,” categorized and incorporated these data into GIS to generate preferred trails for recreational planning and analysis. Milakis and Athanasopoulos (2014) derived weighting scores for a set of criteria from a group consisting of 3 research team members and 10 experienced cyclists who had used bicycle as their main transportation mode in the previous two years. Cyclists in the group were informed the logic of each criterion in two meetings. After clarification, participants submitted their weight scores. The results of individual weighting were calculated and apply to identify optimal routes. GIS was used to quantify and map urban and road environment characteristics.

In short, while quantitative data generated from nationwide surveys and by technical base approach will continue to be useful for bicycle research, local governments face challenges in collecting and incorporating locally context-sensitive data into GIS for strategic plan of bicycle facilities. The case study presented in this paper can fill the need of local governments to engage the public in bicycle strategic planning with limited research and expertise, and enrich the existing literature in this regard.

THE CITY OF GRAND PRAIRIE, TEXAS

The City of Grand Prairie is located in the center of the Dallas-Fort Worth-Arlington Metropolitan Statistical Area (DFW MSA), with close proximity to the DFW International Airport in the north, the City of Dallas in the east, the City of Fort Worth in the west, and Joe Pool Lake, a fresh water impoundment (reservoir) and a major recreation attraction in the DFW metroplex, in the south. Two major interstate highways, I-30 and I-20, run east-west through the northern and southern parts of the city (Figure 1). Because of its unique geographic location, Grand Prairie is also a well-established distribution center. Most warehouse, distribution and manufacturing buildings are in the north. Major retail activities are concentrated along I-20 (City of Grand Prairie, 2015). Like many cities in the metroplex, Grand Prairie has experienced rapid population increase since the turn of the century from 128,025 in 2000 to 175,396 in 2010 and 185,453 in 2014 at an average annual rate of 3.2%. The demographic composition of the city is diverse and family-oriented. According to the 2010 Census, close to half (47.4%) of the population were non-white and about 42.7% were Hispanic. Among all households, about 74% were family households and 40.8% were those with children under 18 years. The median household income was $53,927 (U.S. Census, 2015a, 2015b).

Figure 1. The City of Grand Prairie in the DFW Metroplex[1]

STUDY APPROACH

Recognizing the potential of technology-based solutions or formal surveys to aid data collection for bicycle and pedestrian planning and the tradeoff between cost and accuracy, this case study adopted a mix-methods approach to gather public input data in order to understand residents' cycling patterns, needs, perceived barriers to cycling and preference for cycling facilities in the City of Grand Prairie. The [1] mix-methods approach included an intercept survey and several small group meetings. The nonprobability sample design was used in this particular case because of the quick turn-around requirement and exploratory nature of the study with no financial resource. Given the limits, efforts were made to reach out as many stakeholders as possible. Specifically, public gathering locations were strategically selected for the individual face-to-face interviews. Examples of these locations are shopping malls, libraries, parks, schools, and post offices. These locations are displayed in Figure 2.

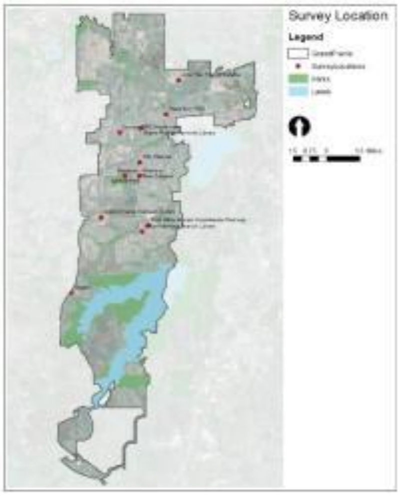

Figure 2. Data Collection Locations

A total of 120 face-to-face interviews were completed during the period of time between March 25 and April 1, 2014. In order to maximize the number of responses, the interview questionnaire was intentionally designed to be short and focused. Therefore, gender, age, and race/ethnicity questions were not included in the questionnaire.[2]

In addition to the intercept survey, several small group meetings with targeted stakeholders were held at various offices in City Hall during April 1st and 2nd, 2014. The participants of the group meetings include four policemen, four representatives from the local school district and YMCA, and three from the city manager's office. The largest groups are the Home Owners Association and the city's Health and Safety sub-committee, with 12 and 11 participants in the respective groups. The participants were in general adults with varying ages and both genders (Guenzel, 2014).

Besides the interviews and small group meetings, socio-demographic data, transportation network and other activity/service data were collected from the U.S. Census Bureau and the North Central Texas Council of Governments (NCTCOG). The data collected through

[1] Source: City of Grand Prairie, 2015
[2] Instead, age and gender of each respondent were recorded by each interviewer.

interviews were analyzed and the results were supplemented, where available, with additional data collected from small group meetings. ArcGIS was used as a decision-supporting tool to analyze the spatial landscape of activities and to assess the effectiveness of the bicycle plan scenarios. More specifically, based on the public input data on usage, barriers, and preferences, the ArcGIS was used to identify locations of parks, residential neighborhoods, commercial centers and schools, as well as connections among them. The Network Analyst was used to calculate the service area based on the local street network and the connections between parks and neighborhoods within a half mile, 1 mile, and 2-mile distance, which are the three preliminary bicycle plan scenarios explored in this study.

RESULTS OF PUBLIC INPUT

1. *Bicycle Usage*

Information on bicycle usage was gathered from questions on the purpose, location, frequency, and distance of cycling. The data indicate that quite a few people own bicycles and use them. However, bicycle is mostly used for recreational purpose but rarely for utilitarian purposes. Frequency of travel is moderate while distance is generally short. These findings are similar to, though slightly higher than, the nationwide bicycle travel patterns (ABW, 2014; Kuzmyak and Dill, 2012; McGuckin, 2011). For example, about 67% of the respondents indicated that they currently owned a bicycle. According to McGuckin (2011), “nearly half of driving age adults have access to bicycle”.

Table 1. Examples of Cycling Locations

Usual Cycling Locations
Various residential neighbor
South Grand Prairie
River Legacy
South of I-20
Mountview Lake
Fish Creek Trail

In addition, close to half of the respondents said yes when asked if they biked in the City of Grand Prairie. In comparison, only 3% of the respondents indicated using bicycle to arrive at the interview locations for their activities. When asked to name the locations in the city where they normally cycle, most respondents (about 80%) listed public parks or the residential neighborhoods where they resided. Table 1 shows some of the common responses concerning cycling areas and destinations. The finding is consistent with the national finding, as about 62% of the trips by bicycle were for social or recreational purpose (ABW, 2014).

Data gleaned from small group meetings in general align with the above findings. For example, participants in the YMCA/School District, policeman, and Health and Safety sub-committee meetings stated that “people enjoy biking across the lake and through the parks,” “mainly adults are biking in the lake ridge,” “people bike for fresh air, family time, and exercise,” “people are using bikes on the streets mostly for recreational purpose.” Lake Ridge, Lone Star Park, Joe Pool Lake, Central Park as cycling locations were mentioned in other meetings as well.

When asked about cycling frequency, only a third of the respondents (32%) indicated that they cycled daily or weekly, and a similar percentage (40%) indicated that they cycled monthly or occasionally (Figure 3).

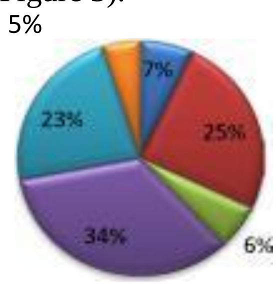

Figure 3. Frequency of Cycling

Cycling distance is short. When asked about cycling distance, the majority of those who biked indicated that they typically cycled 2 miles or less during a single trip (58%). Another 22% responded that they cycled 2 to 5 miles (Table 2). In comparison, the nationwide average bicycle distance was 2.3 miles (Kuzmyak & Dill, 2012). Data of cycling frequency and distance are consistent with cycling purpose. Together the data suggest that most respondents are casual cyclists.

2. Barriers to Cycling

A main objective of the interviews was to understand the barriers to cycling. This was accomplished by asking respondents to identify factors that would discourage bicycling. Nine factors were listed. Respondents could pick multiple factors from the list. Figure 4 shows the frequency of respondents choosing each factor. The data reveal that safety and lack of cycling places are top concerns to the respondents. “No place for a bicyclist to ride” and “heavy or fast-moving traffic” were perceived by most respondents as the primary barriers to riding a bicycle. The next two top concerns related to constraints of cycling places included “bicycle lane or paved shoulder missing” and “no space for bicyclist on bridges or in tunnels.” Safety concerns, such as poorly lighted roads, problematic intersections and road surface, and heavy traffic were also noted by a significant number of participants.

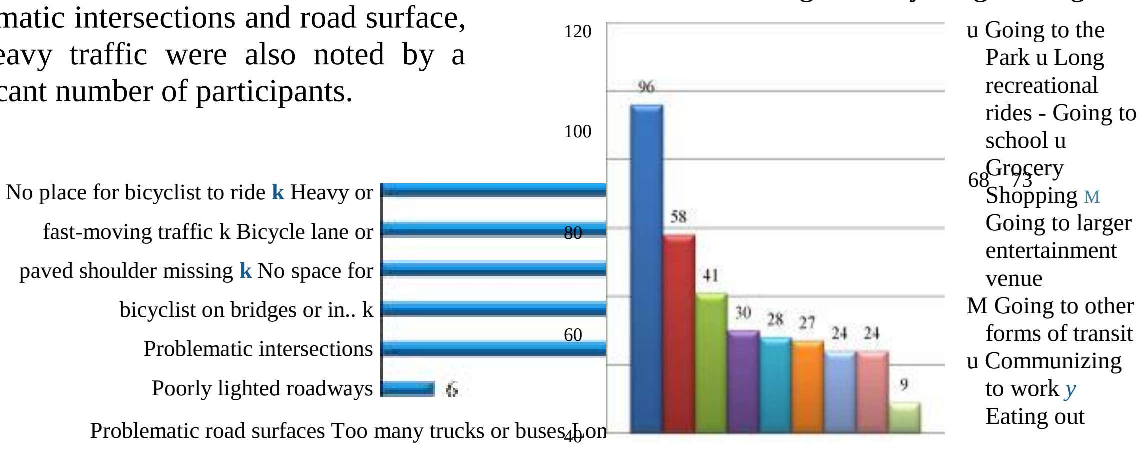

Figure 4. Factors Discouraging the Likelihood of Bicycling

The concerns over lack of cycling places and safety are reinforced in the response to the open- ended question: “Is there anything else that you think we should know?” While there were close to 100 remarks, a noticeable theme is the concern over safety. The majority of comments related to bicycle safety were on interaction with automobile traffic from two perspectives: drivers fearful of hitting a cyclist and cyclists in danger of getting hit by an automobile. Many commented on educational programs to inform cyclists and motorists of safer riding protocols. This sensation resonated with parents fearing for the safety of their own children riding to school even at short distances due to hazardous riding conditions. Interviewees also mentioned the need for sidewalks often. Crime as a general safety issue was also brought up during the interviews.

Table 2. Cycling Distance

Cycling Distance	Frequency	Percent	Valid Percent	Cumulative Percent
Around the block	15	13%	19%	19%
% - 14 miles,	11	9%	14%	33%
/ -2 miles	20	17%	25%	58%
2-5 miles	17	14%	22%	80%
More than 5 miles	16	13%	20%	100%
N/A	41	34%	100%	
Total	120	100%		

Safety concerns and needs for safe routes for walking and cycling emerged from small group discussions. “We don’t want to ride next to the traffic,” said someone at the homeowner association meeting. Policemen were concerned about bikers' safety and congestion. They recounted accidents of cars running over bikers. The concerns were reflected in such comments as: "I would like to see the current bikers to be safe," "putting bike lanes in the roads will increase [rush hour congestion]," and "size of the roadway cannot accommodate a bikeway." The same concerns were echoed at the school district/YMCA and Homeowner Association (HOA) meetings: "riders were killed on Robinson Road," "there is no room for walking or biking," and "south neighborhoods do not have good sidewalks." The participants at the HOA meeting also discussed crime and lighting issues. Some said that "[putting] bikes and cars together is a problem."

3. Preference for Cycling

A number of questions were designed to gain information about cycling preferences. These questions include the intended use of the cycling system, as well as the preferred type and support facilities. When asked what the interviewees would use the cycling system for, the most common response was "going to the park," followed by "for long recreational rides." About a third of the respondents indicated that they would also use the system for school trips (Figure 5). The responses were very similar to the responses to current bike usage, and suggest people favor a bicycle system that meets their recreational needs.

Figure 5. Number of Responses to Intended Usage of the Cycling System

When asked what types of bike lanes the interviewees would use, most respondents preferred bike lanes within neighborhoods or going to parks (80%). About half also selected bike lanes with some on-street trails between home and shopping and about a third chose bike lanes with on-street commuting with moderate automatic traffic. The most preferred bike support facilities were bike racks (80%), followed by more trees and shades (41%), as well as covered storage area (29%).

Numerous suggestions on cycling routes and facilities were made at all the small group meetings. Some examples of comments are: "the road needs to be widened," "signs need to be on," "I might like to see some bike lanes-connected through off-street and on-street," "parking areas for biking will be needed," "there are lots of pockets in the city, linking those will be helpful," "bike trails/walking trails through power line will be cool, that will establish good east-west connection," and "Macfalls Park is good for trails."

In summary, the interviews and small group meetings suggest a number of messages:

a) Bicycles are used mostly for recreational purpose;
b) Cycling distance is usually shorter than 2 miles;
c) Parks and neighborhoods are common cycling locations;
d) Lack of cycling places and safety are major concerns of cycling;
e) A safe bike system is preferred to connect parks, schools, and neighborhoods;
f) Bike racks, streets with trees, and covered bike storage areas are seen as supporting facilities for cycling.

GIS AS A DECISION SUPPORT TOOL FOR STRATEGIC PLANNING OF BICYCLE FACILITIES

The above findings have a number of implications for bicycle planning:

a) The focus of the bicycle plan should intuitively connect residential locations with park and recreation centers while maximizing the connections to other activities.
b) To address the safety concern, highways and major arterials with high speed and traffic volume should be excluded from the planned bicycle route system.
c) From a user's perspective, priority should be given to short distance of travel.

d) From an implementation's perspective, neighborhood streets close to parks and recreation locations should be given priority. This will not only address the immediate needs of bicycle travel, but also increase the implementation pace with less cost, as bicycle lanes can be dedicated and improved easily on neighborhood streets than on main streets.
e) However, from a social equity's perspective, priority should be given to those with socioeconomic disadvantages.
f) Bicycle support facilities and landscaping should also be planned accordingly.

Based on the insights into bicycle usage and travel distance, three scenarios are explored for public discussion and decision making. Scenario #1 will focus on neighborhoods within a half mile local street network distance to parks and recreation centers. The other two are scenarios with a street network distance of one and two miles, respectively. By focusing on local streets and linking residential locations to parks and recreation centers, these scenarios address the first four bullet points of the public input. However, social equity is an important goal of bicycle planning. The effectiveness of the scenarios needs to be assessed. Some questions that can provide useful information for the assessment include:

a) Where are the respective areas under each scenario?
b) What is the extent of the service area covered by the bicycle plan scenarios?
c) Who will be affected under each planning scenario?

These questions are important for public discussion and decision making. To answer these questions, spatial data of the existing transportation network, land use, employment, and the 2012 American Community Survey for the City of Grand Prairie were collected. GIS was used to analyze the data. Figure 6 is a visual display of the employment, educational, commercial, and residential service coverage areas under the 1 mile scenario.

Table 3. Effectiveness Indicators of Bicycle Plan Scenarios

	City Total	**Bicycle Plan Scenarios**		
		1/2 mile	**1 mile**	**2 mile**
Employment				
Employment Served	26360	14.73%	27.97%	52.12%
Commercial				
Commercial Center Served	614	29.80%	64.98%	84.53%
Education				
School Served	64	34.38%	64.06%	82.81%
Residential				
Total Population	167,647	26.71%	58.56%	80.35%
Population Aged 20-40	52,150	25.82%	56.09%	79.46%
Non-White	62,288	22.28%	50.43%	75.09%
Hispanic	71,700	33.95%	69.59%	88.15%
Household w/ Income < 40K	20,023	29.14%	61.29%	83.10%
Residential Area (Sq. Ft)	454,734,650	55.74%	65.78%	85.90%

The spatial analysis generates a number of indicators for assessing the effectiveness of the bicycle plan scenarios. These include the numbers of employment, commercial centers, and schools covered by the service area under each scenario. The criteria for residential locations include the neighborhood area as well as the number of population, persons aged between 20 and 40 years old, non-white, Hispanic, and household with income less than $40K. The age and income indicators are selected based on the findings on age and income in several studies by FHWA (2010);

Kuzmyak and Dill (2012), ABW (2014) and others. These indicators are selected in an effort to address the equity concerns. Table 3 provides the key indicators under the three scenarios.

The results of analysis indicate that under the half-mile scenario, slightly more than half of the residential neighborhoods will be served. However, only about a quarter of the total population and those aged 20-40 would be served, though the service area would cover about a third of the total Hispanic population, and to a less extent the households with income less than 40K. Less than a quarter of the minority population would be served under this scenario. This option would also provide connection to about a third of the schools and about 30% of the commercial centers in the city. The connection to employment locations would be the least.

In comparison, the 2-mile scenario would increase the effectiveness of bicycle plan to cover the majority of the population, especially the Hispanic population households with income less than 40K. This scenario would also increase the connections to education and commercial activity centers and significantly improve the connection to employment centers from about 15% to 52%.

CONCLUSION

This paper presents the findings on bicycle usage, user needs, and perceived barriers to cycling based on public input gathered from an intercept survey and small group meetings with targeted population in the City of Grand Prairie, Texas. The non-random sampling techniques were used due to the limit on financial resources and the quick turnaround time requirements. Efforts were made to address the shortcomings by selecting locations for interviews strategically and reaching out to key stakeholder groups through small group meetings. While the results may not be representative, the findings surprisingly resemble the national bicycle travel patterns. The study adds knowledge to the current understanding of bicycle travel, needs, and barriers. The approach is useful for local governments to meet their immediate needs and to promote active transportation with limited resources and time.

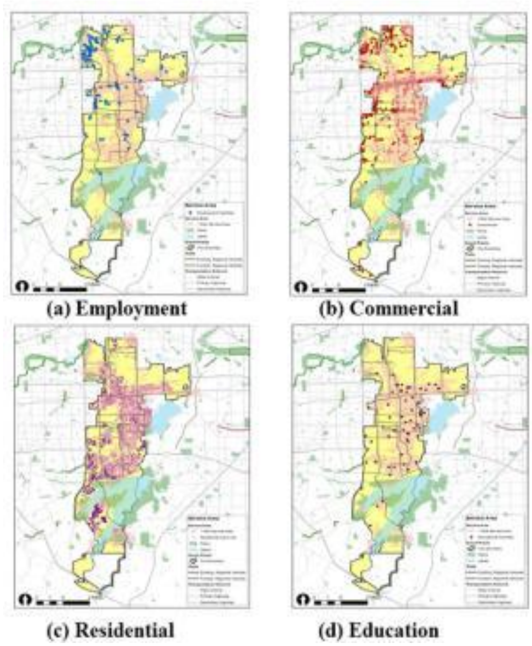

Figure 6. Spatial Coverage of Bicycle Plan Scenario #2

It also illustrates the use of GIS to incorporate public input in bicycle scenario planning and aid public discussions. GIS is mostly used for quantitative data. This study shows the potential to incorporate qualitative public input in GIS for bicycle planning. Due to the time constraint, the spatial analysis in this study is preliminary and exploratory in nature. More work can be done to fully take advantage of the GIS, as many issues in bicycle planning are location-specific and GIS can empower planners and the public to think spatially and make decisions from a spatial perspective.

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