A Survey to Investigate Transport Conditions in Depopulating Cities in Illinois

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Abstract

Despite the global population increase, many cities in the world are depopulating. While the literature focuses heavily on the challenges brought by an increasing population, depopulating cities face many challenges as well. In particular, the management and maintenance of infrastructure often becomes challenging in depopulating areas. To identify the challenges related to transport, this study conducts a survey on depopulating cities in Illinois. Asking questions about the availability of travel modes, the challenges faced by users of each mode, commonly/possible implemented solutions to facilitate mobility, and investment and funding in transport, this study provides an analysis of transport conditions in depopulating cities from an administrative standpoint. A descriptive analysis of the survey responses is presented to provide aggregated results and to exhibit how responses vary with city size and location. This study also highlights the importance of evaluating existing conditions to implement tailored solutions to local contexts instead of applying blanket solutions that often fail to benefit the residents.

Keywords: Depopulation, Survey, Transport, Aging, Disability

Introduction

While the global population is on rise and many cities keep growing (1), many urban and rural areas alike are also depopulating. In Europe and Japan, trends of depopulation in many cities began as early as the second half of the 20th century and are predicted to continue until the end of the 21st century (2). These trends of depopulation are also expected to expand to developing countries in the coming years (3). In the United States (US), many states have been losing population (4,5). Different studies have been carried out in Europe, Japan, and the US to identify the reasons behind depopulation and the subsequent challenges it brings (6–10). The migration of younger populations in search for a better life and low fertility rates are considered as major demographic reasons behind depopulation (11), resulting in communities with a high proportion of older populations (12). When depopulation combines with aging, existing mobility challenges often worsen since driving becomes more difficult and unsafe. In fact, studies on European Union (EU) cities found mobility and aging to be among the major challenges when cities are losing population (13). Therefore, easier access to public transit (PT) and/or availability of alternate travel modes become a necessity to ensure adequate mobility. Being a car-based society, mobility challenges in the US become even more salient in depopulating areas since both the physical infrastructure and a managing agency are often unavailable to operate a PT service. To ensure an inclusive society, providing accessibility is essential as accessibility is a measure of livability (14). Therefore, it is important to find the mobility challenges in depopulating cities in the context of the US to prepare for a better future (15,16).

The main goal of this study is to develop and deploy a survey and to analyze the responses to investigate transport conditions in depopulating cities. Specifically, this study aims to identify:

- the transport challenges faced by depopulating cities,
- possible solutions based on the responses of city mayors/ village presidents/ clerks, and
- how these challenges and solutions differ among depopulating cities with respect to their size and location.

To meet these objectives, we surveyed depopulating cities in Illinois. Here, the term "city" refers to a "Place" as defined by the US Census Bureau. According to the definition, 'Places, in general, are organic and they expand (or contract) over time as the population or commercial activity increases (or decreases)' (17). Places include towns, cities, villages, and boroughs. In Illinois, Places only include cities, villages, and boroughs, and do not include towns or townships. These classifications of Places are built upon population count. Therefore, rather than focusing on specific cities or metropolitan areas, this study investigates all Places in Illinois since the aftermath of depopulation is not limited to geographically delimited villages or municipalities. Moreover, when analyzed at the macro level (e.g., county or metropolitan scale), the effects of depopulation are not clearly captured since urban sprawl may compensate for the population loss in the inner-city (18,19). However, population loss from an inner-city can eventually propagate to the peripheral cities if the vitality of the region is not maintained (20). Besides, micro-level investigation helps to identify the issues in specific detail and can help to design tailored solutions.

In this study we collected information about roadway transportation system in depopulating cities in Illinois and presented the aggregated findings. This information can aid the depopulation literature by providing an analysis of roadway transportation in cities of different sizes and geographic locations in a car-dependent society and present their expected solutions from an administrative standpoint.

The next section offers a brief review of the literature. The third section presents the survey design and recruitment process along with the rationale behind the questions. The fourth section outlines the main survey findings. Finally, the conclusion and discussion section discuss the insights gained from the survey.

Literature review

From a planning point of view, a declining population is generally viewed as negative (21). In fact, cities seldom account for depopulation in their planning. A decreasing population translates into a reduced tax base, making it more difficult to find the financing for infrastructure maintenance (22). Downsizing existing structures has been discussed as a solution; however, it is neither popular nor necessarily effective (23,24). For example, in western Massachusetts, population decline is causing revenue shrinkage which is limiting investments in critically needed infrastructure, further propagating the negative trend of demography and economy in that region (25). Moreover, a reduced workforce to manage aging infrastructure in declining population areas can limit the industrial and commercial base. Meanwhile, a study on depopulating rural areas in Mediterranean regions found that abandoning lands in mountainous regions led to water regulation and soil retention for lowlands causing an increase in agricultural fertility in lowlands (26). A quantitative study on infrastructure in Japan showed that infrastructure development and management can be problems in depopulating regions, largely dependent on geographical conditions and existing policy situations of the region (11).

To find how infrastructure systems are affected and managed in depopulating areas, several studies have analyzed infrastructures such as transport, water and wastewater systems, telecommunication, housing, and healthcare services (11). In the US, most studies have focused

on water and wastewater systems in depopulating cities (23,27,28); only a few have discussed transport (23). To find the prospect of PT in depopulating cities in Japan, studying a midsized city, Kii *et al.* (29) expressed their concern that, with depopulation, congestion stops being an issue, therefore making people less likely to use PT, while improved service quality will increase PT-use in densely populated areas. They emphasized that transport plans must be analyzed along with how the land use pattern is evolving since land use has a longer temporal impact on the neighborhoods than transport. According to the World Economic Forum, Mobility as a Service (MaaS) has become popular in rural Japan to provide connectivity to bus stops for elderly communities. Although MaaS often works on a digital platform, in Choisoko, Japan, the authorities have instead adopted non-digital media to reach the aging population that is not as comfortable with digital tools as younger populations (30). While Japan prioritizes local uniqueness when providing PT, the existing policies for transport funding in EU countries depend largely on the territorial classifications (31). Being driven by economic features, the EU is more focused on traditional transport modes rather than benefiting the transport system from unique demographic and spatial attributes of the places. Bisaschi *et al.* (31) suggested that by concentrating on equity and changing the existing funding policies, EU countries can revitalize their depopulating regions.

Methodology

To capture the uniqueness of the cities and the challenges they face, we designed a survey in which we ask city officials about the current conditions of their roadway transportation systems and their suggestion to facilitate the mobility of the residents. The following section discusses the details of the survey design and the recruitment process.

3.1 Survey design

The survey questionnaire was designed to identify the challenges linked with the existing transport systems and the more general mobility challenges faced by residents in the depopulating cities in Illinois. The method of identifying the depopulating cities and their extent of population loss can be found in the Supplementary Material (section A). The questions of the survey covered a variety of topics, including availability of travel modes, challenges faced by users of each mode, possible solutions for each mode, coordination among PT services, transport investment criteria, and funding sources (more details below).

The intention was to provide a general platform for very small to large cities to collect information about the challenges faced by different transport mode users and possible solutions from the perspective of city officials. The rationale for the selection of questions is presented in Table 1. Since cities have their unique attributes and to seek and implement adaptive solutions, this uniqueness can be an asset. The survey included open-ended questions for city-specific suggestions.

The survey consisted of 47 questions, administered online using Qualtrics (a web-based survey platform). Most questions were multiple-choice; the remaining questions were open-ended questions asking for comments and suggestions. All multiple-choice questions offered an input text option to make the choice options mutually exhaustive. The complete survey questionnaire can be found in the Supplementary Material (section B). The questions can be classified into four broad groups:

- General information
    - Economy

    - Available transport modes and service extent
- Challenges and possible solutions
    - Challenges for each mode user
    - Solutions for each mode user
    - System solutions irrespective of mode
    - Transport for people with physical disabilities
- Innovation impacts
    - Expected impacts of widely discussed transport sector innovations
- Miscellaneous
    - Ongoing transport projects
    - Funding sources
    - Project investment decision drivers
    - Community engagement
    - Internet availability
    - General comments and suggestions

Table 1 Survey questions section and rationale

Section description	**Rationale**
Economy	Economic decline is often discussed as a major indicator as well as a cause of depopulation (32–34). Economic sectors have been chosen from the available economic sectors as per US census.
Available transport modes and service extent	The focus of this survey is transport. An assessment of existing transport conditions is the first to step to identify existing/ upcoming challenges and possible solutions. Here, by mode we refer to road transportation modes only, since regular localized travel in Illinois is dominated by roadway transportation.
Challenges for each mode user	
Solutions for each mode user	

System solutions irrespective of mode	By system-based solutions, we refer to optimization or development works that improve the overall performance of the transport system rather than focusing specifically on each mode.
Transport for people with physical disabilities	According to Bureau of Transportation Statistics (BTS), based on 2017 National Household Travel Survey (NHTS) data, a larger share of people with disabilities ride as passengers in personal vehicles than people without disabilities. Since depopulating cities often lack sufficient PT services—noting that with aging comes age-induced disabilities as well (33)—providing access to people with physical disabilities becomes imperative.
Expected impact of widely discussed transport sector innovations	Transportation Network Companies (TNCs) are becoming popular as a MaaS solution in depopulating regions in Japan and Netherlands (35,36). Moreover, Autonomous Vehicles (AVs) when deployed nation-wide are expected to change the state-of-art in transport.
Ongoing transport projects' type	In depopulating areas, population density becomes low, resulting in higher per capita cost for infrastructure (37), therefore requiring an increased investment in infrastructure management and maintenance. Trends in infrastructure development can be an indicator of cities' future economic trends.
Funding sources	Funding is a critical issue in depopulating cities; funding policies and regulations often dictate the revitalization of depopulating cities (31). Non-traditional fund sourcing or alternative sourcing options can change the trend of the city. Also, learning about the obstacles faced by different cities can help to tailor policy for declining cities.
Project investment decision drivers	Oftentimes, growth-based decision results in oversized infrastructures (21).
Community engagement	The literature on depopulation shows that better community engagement provides more sustainable policy solutions (38,39).
Internet availability	Demand-responsive transport solutions are mostly managed through smartphone and web applications, and digital illiteracy is a barrier for the aging communities to access these services (40).

3.2 Recruitment Process and Responses

The primary participants of this survey are city mayors/ village presidents/ clerks from the depopulating cities in Illinois. In the remaining section of this article, the participants will be stated as 'city officials.' For some cities, transit agencies were contacted to respond on behalf of the city when responses from city officials were not available. Transit agencies were provided with the same questionnaire and asked to respond on behalf of a specific city under their transit jurisdiction since transit companies rarely operate within the geographic boundary of one city.

Out of the 469 cities that were identified as depopulating at different scales (shown in marron in Figure 1), email addresses for 252 (53.7%) cities were obtained from their official websites or were available online from the Ameren Illinois Company, county websites, Facebook pages, and via phone calls.

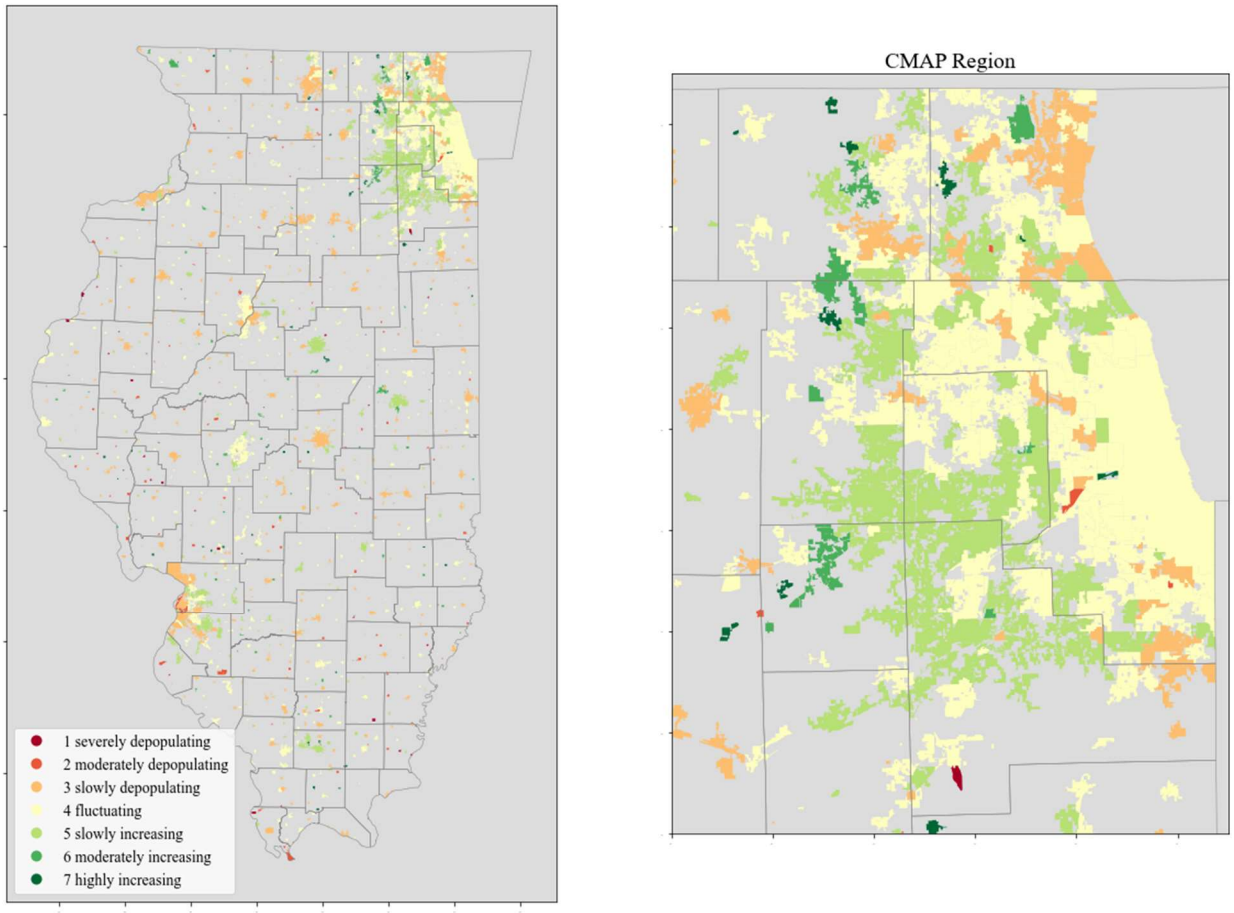

Figure 1 Population trends in cities of Illinois

Survey questions were sent to all these addresses via email. There are 25 Census Designated Places (CDPs) among these depopulating cities. CDPs do not have separate governments (41); hence they were excluded from the survey. Among the 252 cities emailed, 72 cities responded to the survey. Out of these 72 cities, 51 cities (i.e., 10.9%) completed the full survey while 15 cities completed more than 61.7% of the survey. This percentage covers questions about transport

challenges and possible solutions per mode. These 66 (14.0%) responses were analyzed to explore the transport situation in depopulating cities in Illinois. In case of multiple responses from one city, the response with maximum answers was used in the analysis. The reason for this was to avoid the response with fewer number of answers since that may have been mistakenly submitted before answering all the questions. The data collection period lasted 5 months, from February 2022 to June 2022.

Our study [protocol number: 2022-0047] was approved by the University of Illinois Chicago (UIC) Institutional Review Board (IRB) offices. Participants were informed that their participation is voluntary and that their responses will be shared anonymously and in aggregated form. An online informed consent was obtained from every survey respondent.

Survey findings

The results are presented in six sections. First, an aggregated result of the challenges and possible solutions for different mode users is presented with a general overview of the survey. Then, data are grouped by population size in cities and distance to metropolitan areas to investigate whether the responses differ based on the size and location of the cities. Subsequently, the system-based solutions, challenges for people with physical disabilities, prospect of emerging technologies in transport system and investment criteria are presented in aggregated form. Note that the sample size varied for each section since both partial and full responses were used in the analysis.

4.1 Overall findings for cities

From the survey, we find that the major economy of depopulating cities is Farm employment, followed by Retail trade, and Healthcare and social assistance. 27.3% (out of 66) of the survey respondents (city officials) mentioned residents do not face a serious mobility challenge without a car. A further analysis revealed that 55.6% of these responses come from cities having PT services available. In contrast, for responses who say residents face challenges without a car, only 39.6% have any form of PT available. Trips that are difficult to make without a car include work trips, closely followed by trips to healthcare and shopping facilities. 56.1% of the city officials say that their cities do not have any PT services. For the remaining 43.9%, services operate mostly regionally and provide only bus services (62.1%). A few cities have local van services for senior citizens. For transit services with multiple operators, there is always some coordination in terms of schedule, information sharing or via inter-agency agreements. 34.8% of the responding cities have services from TNCs. Some of these cities have paratransit services and township services for special needs that can be booked via phone calls.

Although 27.3% of these city officials think that without a car mobility is difficult, when asked irrespective of mode if residents face challenges to make a trip, this share falls to 21.2%. High fuel cost is the main challenge for private car (PC) users followed by distance to destination and pavement condition. For all other modes, PT, TNCs, bike and pedestrians, it is the lack of physical infrastructure/technical features of the service that is the main challenge. When asked about commonly implemented solutions for each mode to ease trips, for PCs, developing the infrastructures is the most favored solution. For PTs and TNCs, responses include more frequent trips, seating facilities at stops, and promoting the service more generally. For active modes, bike, and pedestrians, providing more comfortable and safe bikeways and walkways are

preferred. Figure 2 shows the top three challenges for each mode and common solutions for depopulating cities from city officials' standpoint.

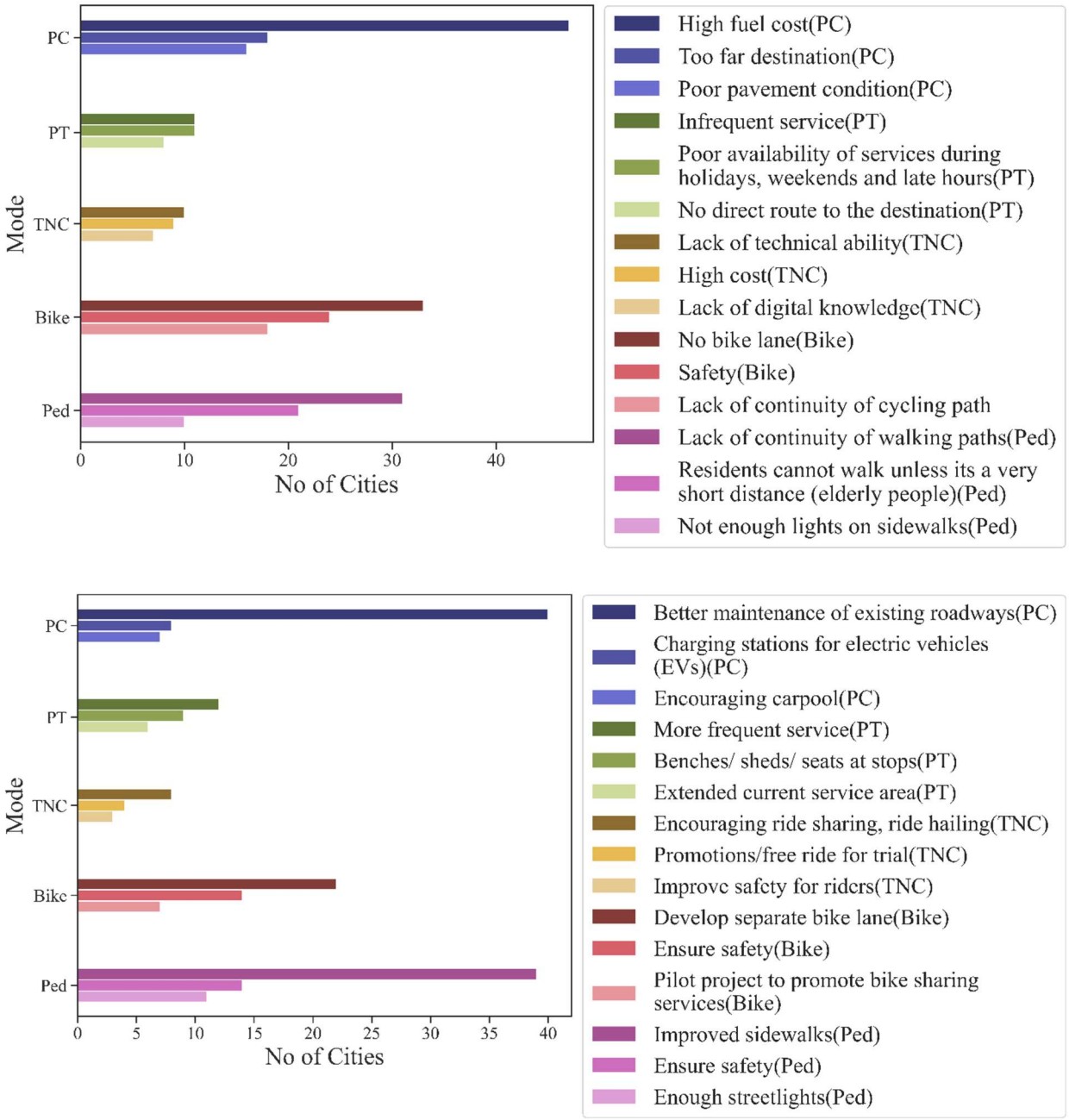

Figure 2 Common challenges and solutions for depopulating cities for each mode

4.2 Cities grouped by size and location

Considering the range of population variation for cities in this study and their distance from a metropolitan area, the results are categorized based on city size and distance to the nearest metropolitan area.

To view how the responses varies with size of the city, cities are classified based on population into five groups as follows: very small (<500), small (501-1000), medium (1001-5000), medium-large (5001-20,000) and large cities (20,000+). When inspected by city size, fuel cost is the major challenge for PC users followed by too far destination. For cities with less than 1000 population, both PT and TNCs are not available services. The demand for TNCs is low in medium and large cities, which implies that deploying TNCs as a regular service might not be a feasible solution for these cities. For PT, in medium-large cities, less frequent service is the main issue while in medium and large cities, poor availability at times and lack of integrated services are the main concerns. For bike and pedestrians, the challenges focus mainly on infrastructure. For example, in small to medium-large cities, having no bike lane is the main challenge, whereas, for large cities, the lack of continuation of the path is perceived as the main challenge. Similarly, for pedestrians, lack of sufficient and walkable sidewalks is the most important challenge irrespective of city size.

When cities were inspected by their distance to nearest metropolitan area, the distance varied from 1.33 km to 168 km with a mean value of 50.7 km. After normalizing the distance, the cities were categorized into six classes based on their distance to the nearest metropolitan area. These categories are within 5%, 6-10%, 11-20%, 21-30%, 31-50%, 51-75%, and 76-100% of maximum distance. When the results are viewed by city locations, the challenges are the same for PC users. In cities close to metro areas, less frequent service during holidays and weekends is

a major issue for PT, while in cities far from metro areas, no direct connection and lack of integration becomes crucial. For TNCs, cities close to metro areas and very distant from metro areas have a lower demand, whereas digital illiteracy is also a challenge for cities that fall in-between in terms of distance. For bike users, the lack of continuity is a challenge for cities close to metro areas while having no bike lane is the major challenges for cities far from metro areas. For pedestrians, the presence of uneven roads is the challenge faced by all cities irrespective of location.

The possible solutions also differ when investigated by city size and location. When the solutions are investigated for each mode by city size the impact of size become more prominent with their respective solution choices. When asked about mode specific solutions for PCs to implement in cities, small city officials supported encouraging carpooling while medium to large cities chose that having charging stations for electric vehicles (EVs) can facilitate PC users. Similarly, for PT, officials from large cities prefer more frequent and improved quality services while officials from medium cities think adding additional stops along the route will benefit the users. Regardless of size, most of the city officials think encouraging TNCs can benefit their cities. For bike and pedestrians, improved bike lane and sidewalk are prioritized as solutions.

In contrast, when analyzed by city location, Autonomous Vehicles (Avs) are popular in cities close to metro areas while more roadway development and carpooling is preferred by distant cities. Similarly for PT, in cities close to metro areas, increasing the service extent and frequency is popular while for distant cities, reducing the vehicle capacity and installing sheds and seats at stop locations are preferred. For TNCs, in cities close to metro areas, the safety of driver and riders are of concern while distant cities' officials think encouraging the TNCs can

improve their residents' mobility. For bike and pedestrians, the choices are similar as the previous ones, developing bike lanes and improving sidewalks.

4.3 Aggregated response for system-based solutions

To find system-based solutions rather than individual modes, the cities were asked to pick from a list of system-based solutions that are commonly implemented in their cities. Out of the 66 cities, 49 city officials responded to this question; see Figure 3. Among them, encouraging bike and scooters were selected by most of the city officials followed by service for special needs population than any other infrastructure development.

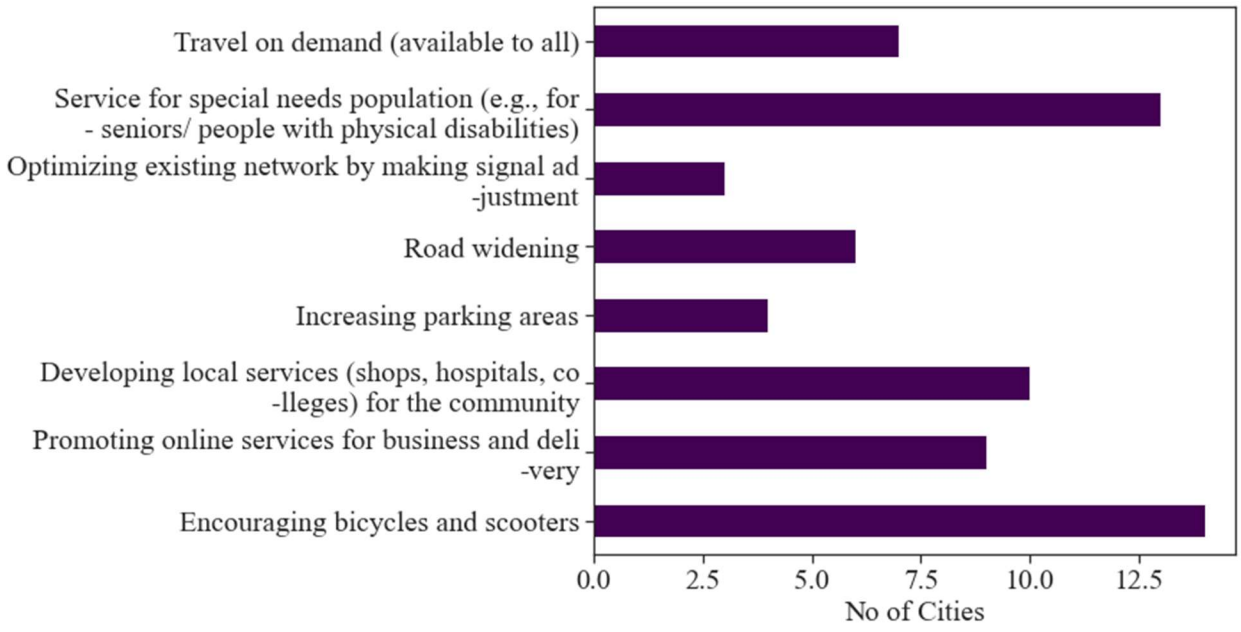

Figure 3 System based solutions implemented in cities

4.4 Challenges for people with physical disabilities

City officials were asked to identify the challenges faced by people with physical disabilities since managing special services for special needs population become more costly in declining

areas. 63 city officials responded to this question. Accessibility to PT followed by noncompliant infrastructure are major challenges faced by people with disabilities in the cities surveyed. Irrespective of size, all cities face similar challenges to accommodate people with physical disabilities in their transport system. These challenges range from lack of available services to noncompliant infrastructure that are designed without accommodating people with disability, and cost of the service. When inspected by distance, in cities close to metro areas, insufficient funding and lack of paratransit services are selected as challenges while, for distant cities, it is the affordability of the users along with a lack of service.

4.5 Prospect of emerging technologies in transport system

To evaluate the prospect of emerging technologies, this survey asked about the innovations either in policy or technology that may benefit transport in these cities. 45% (27 out of 60 responses) of the city officials think integrated pickup and drop-off with PT network can benefit their city. Moreover, rather than choosing from tech-savvy integrated options (i.e., trip-share platforms, AVs) city officials support local business and tourist attraction promotions. The expected impact of innovation varies with city size. While small city officials choose encouraging local business and tourist attraction to boost transport in their cities, medium and medium-large cities think integrated pickup and drop-off facilities can ease their transport system. Low-cost services via TNCs seem a favorable option for cities of all sizes. When inspected by city location, cities that are moderately far from a metro area think they can benefit from TNCs. When asked to pick one transport solution for their respective cities, the most mentioned ones are low-cost TNC services, on demand PT services, low-cost van services for trips to hospitals, banks and grocery, delivery services, and sidewalk improvements.

4.6 Funding and investment decision

Since transport projects are long visioned development projects that take a substantial time to come into effect, cities officials were asked about the challenges they face to implement a project and funding is the most mentioned one. Inquiry about funding sources reveals that cities are normally financed by state funds or local funds based on the size of the city. To identify the investment decision process, how a project is chosen for implementation and to find community involvement in the process, the survey asked about investment decisions criteria. The aggregated responses show that investment decisions are made based on economic development, accessibility, and safety concerns as presented in Figure 4. It should be noted that the extent of terms like accessibility and safety can vary a lot based on the use-context. When asked about community engagement in project decision making, city officials stated that, for 39~53% cities, either residents or representative of the residents participate in decision making.

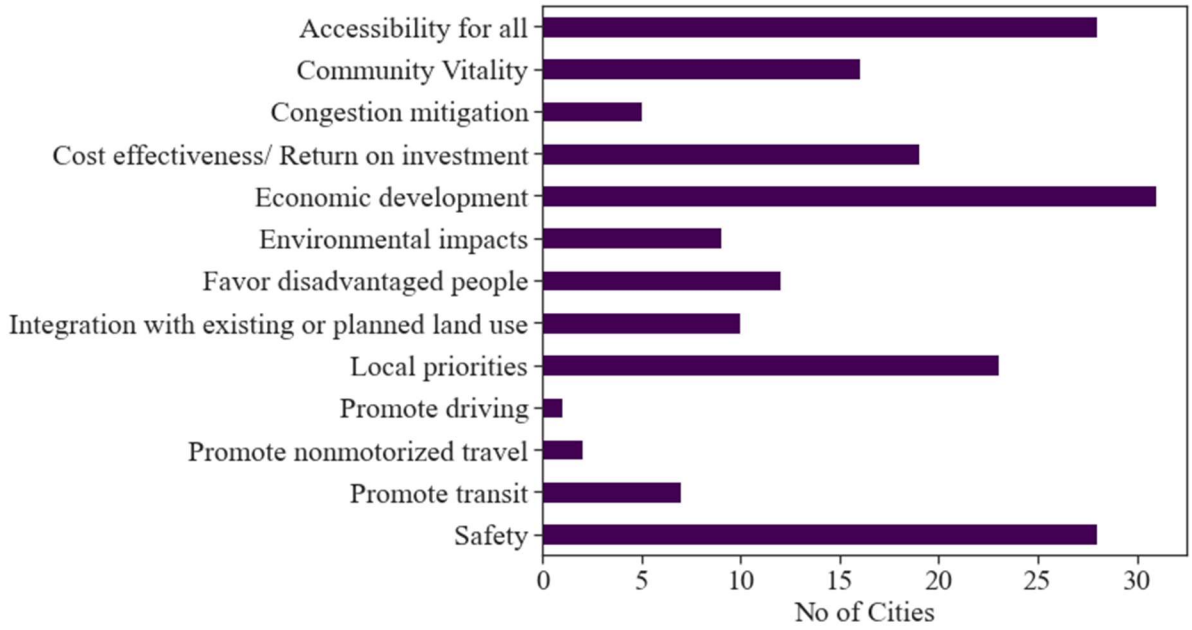

Figure 4 Investment decision criteria in cities

Table 2 shows the number of responses received from each category based on the extent of population change as shown in Figure 1.

Table 2 Responses per labeled category

Labels	Count of Responded
severely depopulating	0
moderately depopulating	6
slowly depopulating	53
fluctuating	6
slowly increasing	1
moderately increasing	0
highly increasing	0

From the table, we see that there are responses from cities where population change rate is fluctuating or slowly increasing. No responses were received from severely depopulating cities while most of the responses received were from slowly depopulating cities. A comparative analysis of survey results for different extent of population loss therefore could not be carried out.

Discussion and Conclusion

This study presented the descriptive statistics of a survey carried out on depopulating cities in Illinois to identify the transport challenges and prospective or commonly developed/implemented solutions. This section discusses the findings from the survey analysis and from open-ended comments and suggestions from city officials.

Studying transport challenges separately for common road transport modes, this study found that, while PC users face similar challenges, the challenges vary widely for other modes. Cities with a very small population cannot promote PT because of the low demand. But city officials stressed the necessity of having low-cost transport services for an aging community to access health care and shopping facilities. In some cities, local services such as hospitals provide pick up and drop off services for residents who cannot access healthcare facilities. Similar services from other providers or a joint venture among multiple providers can ease transport for residents in cities where the demand for PT is low. In some cases, PT services are provided, but the residents are not aware of them. For such cases, promotional offers may encourage users to get accustomed to the services offered. Although TNCs seem promising in some countries as mentioned in the literature, the study results show that their demand changes depending on the size and location of the city. City officials highlighted the need of special transport services for specific communities and promoting local business to provide necessary facilities within the community rather than introducing new transport services or expanding networks.

Access to funds is another crucial factor, especially for small cities. To cope with low funding availability, city officials chose to resurface their roadways instead of repaving them, which poses safety challenges because of the formation of large crowns from consecutive patching and resurfacing, as well as the inability to properly drain the roadway. In addition, the lack of well-developed roads is seen as deterrence to attracting more employment opportunities because of inadequate access.

The study results also reveal that the response patterns vary based on city size and location. Most of the small cities surveyed are located far from metro areas, which is evident from the similarity in the problems they face and the possible solutions. However, the results

demonstrate that, although these cities have similar population trends, the population factor alone cannot provide sufficient information alone about the challenges they face since challenges also differ for different travel modes. The availability of multiple travel modes provides higher accessibility in large cities and cities that are close to metro areas. Therefore, offering a suitable PT service is important for these city officials. In contrast, in distant small cities, having access is the most prominent issue. Survey respondents also underscored the need for improved sidewalks to make places more accessible for people without a car.

This survey highlights the importance of evaluating existing transport situations in depopulating cities before implementing any projects for revitalization of such places. The survey reinforces the fact that despite the presence of common challenges, every city is unique and requires tailored solutions as already emphasized in the literature.

Lasty, this study is not without limitations. The survey was operated online, and there was no scope to explain the intention of the questions to the respondents. Yet, the survey clearly proves that residents of depopulating cities face important mobility issues that should be addressed. This study identified some of the challenges faced and proposed some possible solutions, but detailed work is needed to identify specific solutions, and to measure how effective the solutions can be when they are implemented focusing on the context and scale of cities and the serving communities.

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Supplementary Material

Manuscript Title: A Survey to Investigate Transport Conditions in Depopulating Cities in Illinois

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Section A: Identifying population Trend

A Mann Kendall trend test (MK test) was applied to find the population trend for cities in Illinois, analyzing American Community Survey (ACS) population data for places in Illinois from 2010-2020. The MK test is one of many statistically robust methods that are available to identify whether time series data has a monotonic increasing (or decreasing) trend or not. Since this test is nonparametric, no assumption about the data distribution is required. It should be noted that the minimum number of data points necessary to detect the trend using this method is 3.

Firstly, the null and alternate hypotheses are established. They are as follows:

- **Null hypothesis (H0):** The data does not possess any discernible trend.
- **Alternate hypothesis (H1):** The data is monotonically increasing (or decreasing).

In the MK test, a value in the time series data, say *x* at time *t*, is compared individually to all the values obtained after time *t*. Each earliest measured value is compared to all values obtained later; therefore, for *n* values in the time series data, $n(n-1)/2$ number of pairs are compared.

In the MK test, the difference between the newly measured value *j* and all earlier-measured values *i*, $(y_j - y_i)$, are calculated. The sign of the difference calculated for each pair are taken as integer values of 1, 0, or –1 for a positive difference, no difference, and a negative difference, respectively.

The MK test statistic, *S*, is calculated as follows using equation (A.1):

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sgn}(y_j - y_i) \quad \text{(A.1)}$$

where $sgn(y_j - y_i)$ is calculated with equation (A.2)

$$\operatorname{sgn}(y_j - y_i) = \begin{cases} +1 & \text{if } (y_j - y_i) > 0 \\ 0 & \text{if } (y_j - y_i) = 0 \\ -1 & \text{if } (y_j - y_i) < 0 \end{cases} \quad \text{(A.2)}$$

The test statistic (*S*) is then used to test the hypothesis established above. In general, if *S* is a large positive number, later values tend to be larger than earlier values and an upward trend is indicated. When *S* is a large negative number, later values tend to be smaller than earlier values and a downward trend is indicated. When the absolute value of *S* is small, no trend is indicated (42). The test result showed that 329 cities in Illinois are showing a decreasing trend as presented in Figure A.1.

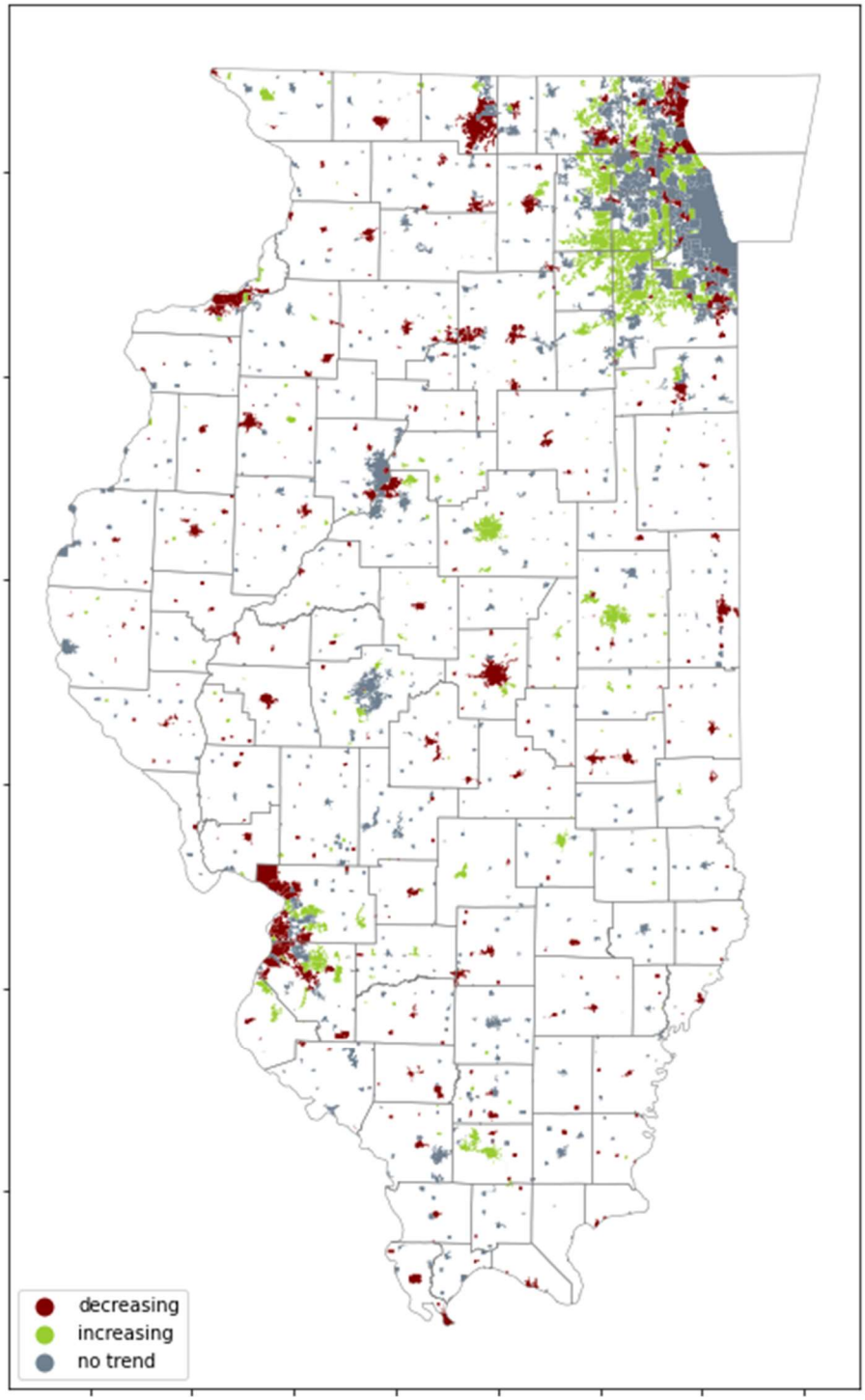

Figure A.1 Population trend from MK test results using ACS data from 2010-2020

Although MK test defines the trend of population, the extent of population change is not captured by the test. Sudden excessive loss or gain in population requires different measures than

gradual loss or gain. To inspect the extent of population change, mean value of annual percent change in population and total percent change from consecutive value of year 2010 and 2020 was used to see how the percent rate varies with the found trend from the test as presented below:

$$\text{Total population change rate} = \frac{P_{2020} - P_{2010}}{P_{2010}} \quad \text{(A.3)}$$

$$\text{Mean population change rate} = \frac{(P_n - P_{n-1})/P_{n-1} + \ldots + (P_1 - P_0)/P_0}{n-1} \quad \text{(A.4)}$$

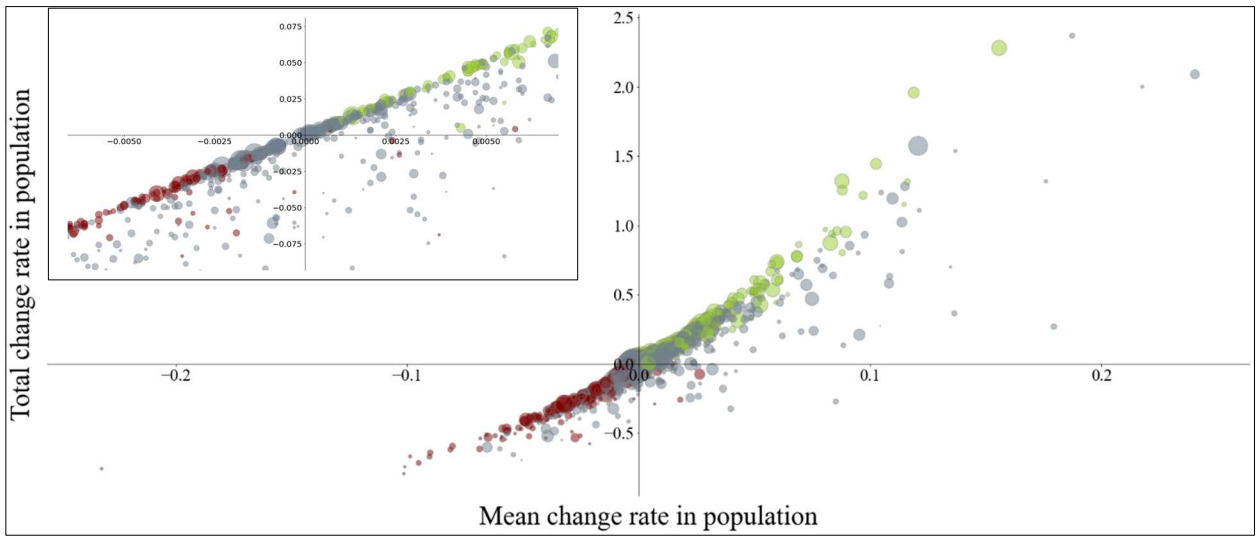

Figure A.2 Total percent change in population vs mean percent change in population from last 11 years data (here, diameter of the markers indicates population density in the cities)

In cities, where data are not readily available or collected frequently, cities are classified as based on census data. But from Figure A.2, the bottom-right quadrant shows that places with a negative total change rate can still have a positive mean change rate when estimates from consecutive years are used for population change rate calculation. This situation refers to cities that are going through consecutive increase and decrease in population and may adapt better than

cities that face successive increase or decrease in population. For micro scale analysis, these consecutive changes are valuable to provide insight of the population mechanism of the cities.

From Figure A.2, it is evident that places that have been classified as 'no trend' are clustered around 0 with a relatively lower mean change rate in population compared to total change rate. Therefore, rather than depending only on population trend obtained from MK test, in this study we classify cities based on three values:

1. Trend in data found from MK test
2. Mean population change rate, and
3. Total population change rate.

Table A.1 shows the cross tabulation based on which the cities were labeled as per their extent in population change. The cross tabulation shows that many cities are clustered around lower mean change rate while their population trends are different.

Table A.1 Cross tabulation of cities based on population trend and extent of population change rate

Mean population change rate	Total population change rate / Trend from MK test	x <=-0.50	-0.5<x<=-0.1	-0.1<x<=0	0<x<=0.1	0.1<x<=0.5	x>=0.5
x<= -0.05	decreasing	18	7	0	0	0	0
	no trend	6	0	0	0	0	0
-0.05 < x <= -0.025	decreasing	4	60	0	0	0	0
	no trend	2	24	0	0	0	0
-.025 < x <= 0	decreasing	1	95	133	0	0	0
	no trend	0	111	194	3	0	0
0 < x <= 0.025	decreasing	0	2	6	2	0	0
	increasing	0	0	0	85	70	0

	no trend	0	10	54	206	70	0
	decreasing	0	0	1	0	0	0
0.025 < x <= 0.05	increasing	0	0	0	0	48	6
	no trend	0	4	4	1	56	1
	increasing	0	0	0	0	3	30
x >= 0.05	no trend	0	1	0	0	16	30

Based on the table, we labeled our cities as follows:

Table A.2 Labeling cities based on population change rate

Mean Population change rage	Total population change rate	MK test trend	Label	No. of cities	Aggregated count
< -0.05	< -0.1 < -0.5	Decreasing No trend	Severely depopulating	31	469
-.05 < x < -.025	< -0.1 < -0.1	Decreasing No trend	Moderately depopulating	90	
-0.025 < x < 0	< 0 -0.5< x < 0	Decreasing No trend	Slowly depopulating	348	
-0.025 <x< 0 -.05 < x< .05	x > 0 -0.5<x<0.5	Decreasing No trend	Fluctuating	550	550
0 < x< 0.025	x>0 0.1<x<0.5	Increasing No trend	Slowly increasing	211	345
.025 < x < .05	>0.1	Increasing No trend	Moderately increasing	71	
> 0.05	>0.1 >0.5	Increasing No trend	Highly increasing	63	

From Table A.2, it is evident that most of the cities are following a consecutive increasing and decreasing trend rather that constant increase or decrease. Figure A.3 shows a map of cities labeled based on the categories of Table A.2. From the figure, we can see that

severely depopulating cities are mostly isolated cities whereas the highly increasing areas are the suburban areas near the Chicago Metropolitan Area.

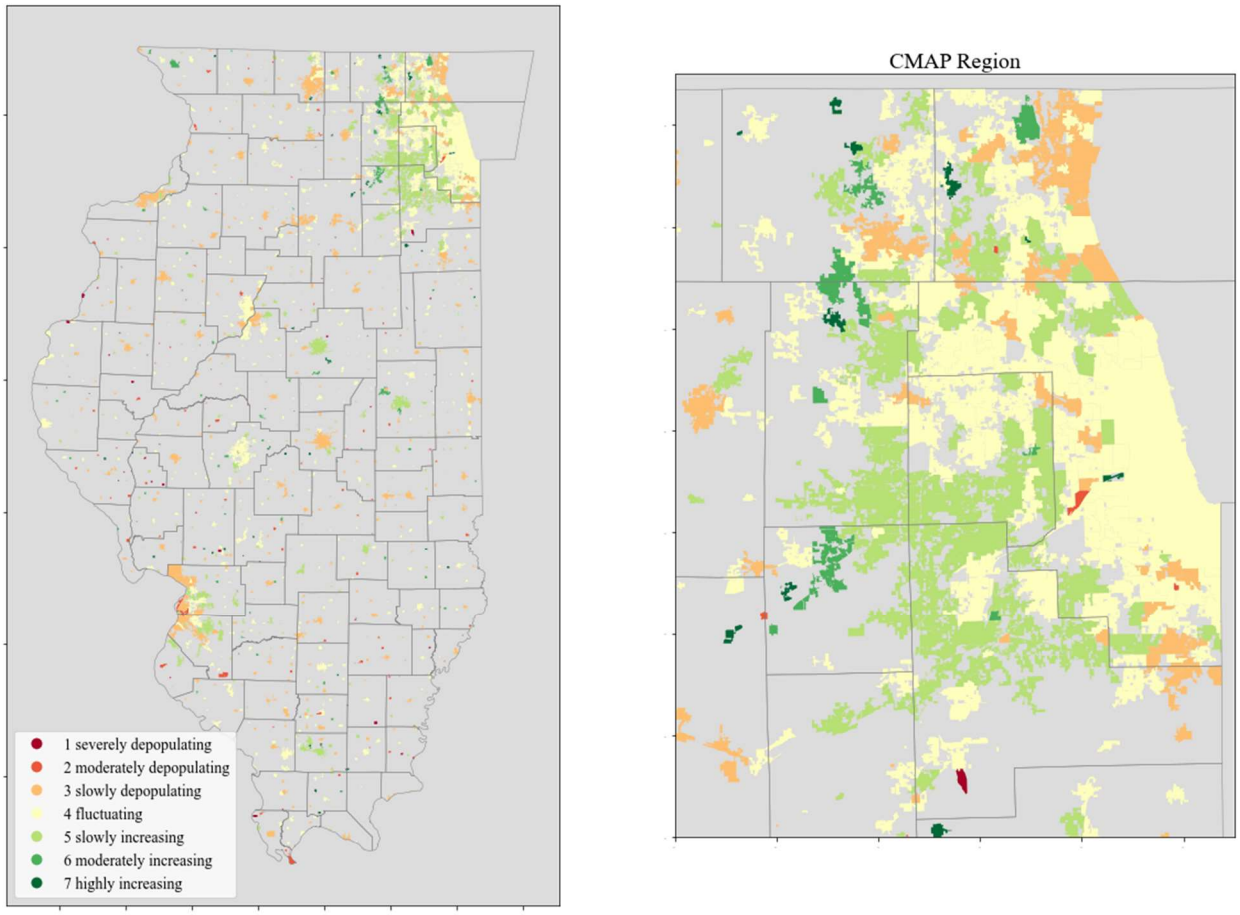

Figure A.3 Cities labeled based on trend, mean and total change rate in population

Section B: Survey Questionnaire

Q0 Consent from

I agree (1)

I don't agree (2)

Q1 For which city are you filling out this survey? (list of depopulating cities)

Q2 What are the major economic sectors in your city? (Select all that apply)

Health care and social assistance (1)

Retail trade (2)

Manufacturing (3)

Professional, scientific, and technical services (4)

Accommodation and food services (5)

Administrative and support and waste management and remediation services (6)

Finance and insurance (7)

Transportation and warehousing (8)

Other services (except government and government enterprises) (9)

Construction (10)

Real estate and rental and leasing (11)

Wholesale trade (12)

Educational services (13)

Arts, entertainment, and recreation (14)

Information (15)

Management of companies and enterprises (16)

Farm employment (17)

Utilities (18)

Mining, quarrying, and oil and gas extraction (19)

Forestry, fishing, and related activities (20)

Q3 Do people without a car face serious mobility challenges in your city (e.g., to travel to work/school/hospitals etc.)?

Yes (1)

No (2)

Maybe (3)

Q4 What are some of the trips that are difficult to access without a car? (select all that apply)

Trip to work (1)

Trip to school (2)

Trip to health care (3)

Shopping trips (4)

Recreational trips (Trips made to a recreational facility/ visiting family or friend) (5)

People still make trips using other modes (6)

I don't know (7)

Other (please specify) (8) _____

Q5 Do you currently have any public transit services in your city?

Yes (1)
No (2)

Q6 To what extent these services operate?

Local (1)

Regional (2)

Both (3)

Other (please specify) (4) _____

Q7 What are the public transit services available in your city?

Bus (1)

Train (2)

Metro (3)

Subway (4)

Other (please specify) (5) _____

Q8 Are these services offered by ____?

Same operator (1)

Multiple operators (2)

Other (please specify) (3) _____

Q9 Is there any coordination among the services? (select all that apply)

Fare coordination (1)

Schedule coordination (2)

Information coordination (3)

Facility and vehicle coordination (4)

Inter-agency agreements (5)

No coordination (6)

Other (please specify) (7) _____

Q10 Who is responsible for the coordination?

Coordinating agency (1)

Unified board of directors across operators (2)

All operators report to the city council (3)

Other (please specify) (4)

Q11 What is the extent of this coordination?

Local coordination (1)

County-level coordination (2)

State-level coordination (3)

Coordination with transportation network companies (TNC) (4)

Other (please specify) (5) _____

Q12 Are there any Transportation Network Companies' (TNC) services available in your city (e.g., Uber, Lyft)?

Yes (1)

No (2)

I don't know (3)

Q13 Mention the names of the available TNCs in your city.

Uber (1)

Lyft (2)

Traditional taxicab (3)

Other (please specify) (4) _____

Q14 Are there any other transport services available (except the ones mentioned above) to meet the specific needs of your city?

Yes (1)

I don't know (2)

No (3)

Q15 What are these services?

_____

Q16 Who do they serve?

Everyone (1)

Low income people (2)

People with physical disabilities (3)

Seniors (4)

Other (please specify) (5) _____

Q17 Do you think, regardless of mode (auto/transit/bike/walk) people face challenges to make a trip to access necessary facilities (e.g., schools, health care, offices etc) in your city?

Yes (1)

Maybe (2)

No (3)

Q18 What are some of the challenges faced by different mode users in your city? (Tick all that apply, you can add additional information in the box)

Q19 Private car users

High fuel cost (1)

Traffic congestion (2)

Poor pavement condition (3)

Poor traffic lighting (4)

Illegal parking (5)

Lack of parking (6)

Too far destination (7)

Other (please specify) (8) _____

Q20 Challenges for public transit users

Infrequent service (1)

Transit fare (2)

Fewer service (3)

Low capacity (4)

Lack of connectivity between public transit services (5)

No direct route to the destination (people have to take multiple modes to reach destination) (6)

Lack of easy access to real-time information (7)

Poor availability of services during holidays, weekends and late hours (8)

Lack of an integrated service connecting neighboring cities (9)

Lack of benches/ sheds/ seats at stops (10)

Not clean (11)

Other (please specify) (12) _____

Q21 Challenges for TNC / shared car users

High cost (1)

Safety issues (2)

Lack of technical ability (too hard to learn for the elderly) (3)

Lack of digital knowledge (application is not convenient to download or to use) (4)

Low incentive (minimum wage for people to work for shared drive company) (5)

Little demand (6)

Not competitive (when compared to other modes) (7)

Other (please specify) (8) _____

Q22 Challenges for bike/bike sharing service users

Topography is not biking friendly (1)

No bike lane (2)

Inadequate bike lane (3)

Lack of continuity of cycling path (4)

Safety (5)

Not enough bikes to use in bike-sharing (6)

Not enough parking stations (7)

Cost of bike-sharing (8)

Other (please specify) (9) _____

Q23 Challenges for pedestrians

Narrow paths (1)

Uneven surfaces (2)

Lack of continuity of walking paths (3)

Lack of green spaces and resting areas (4)

Parking consumes sidewalk space (5)

Not enough lights on sidewalks (6)

Not safe to walk alone (7)

Not safe to walk at night or early morning (8)

Residents don't like to walk (9)

Residents cannot walk unless it's a very short distance (elderly people) (10)

Other (please specify) (11) _____

Q24 What are the common solutions implemented in your city to solve the mobility problems (solutions that are already being implemented/implemented before/implemented on a pilot basis)?

Q25 For private car users

Better maintenance of existing roadways (1)

More roadways development (2)

More parking lots construction (3)

Parking fee reduction (4)

Charging stations for electric vehicles (EVs) (5)

Encouraging carpool (6)

Introducing incentives for some trips (7)

Other (please specify) (8) _____

Q26 For public transit users

More frequent service (1)

Benches/ sheds/ seats at stops (2)

Extended current service area (3)

Additional stops along the route (4)

Reduced capacity vehicles (5)

Dedicated bus lane (6)

Subsidy by the federal/state government (7)

Regional transit development connecting neighboring cities (8)

Other (please specify) (9) _____

Q27 For TNC / shared car users

Promotions/free ride for trial (1)

Encouraging ride-sharing, ride-hailing (2)

More incentives for workers of this services (3)

Improve safety for riders (4)

Improve safety for drivers (5)

Other (please specify) (6) _____

Q28 for bike / bike sharing service users

Pilot project to promote bike-sharing services (1)

Develop separate bike lane (2)

Integrate bike with public transit services (3)

Secured bike parking (4)

Ensure safety (5)

Other (please specify) (6) _____

Q29 For pedestrains

Improved sidewalks (1)

Enough streetlights (2)

Ensure safety (3)

Other (please specify) (4) _____

Q30 Has your city implemented any of the following to solve the challenges people face to access facilities? (select all that apply)

Travel on demand (available to all) (1)

Service for special needs population (e.g., for seniors/ people with physical disabilities) (2)

Optimizing existing network by making signal adjustment (3)

Road widening (4)

Increasing parking areas (5)

Developing local services (shops, hospitals, colleges) for the community (6)

Promoting online services for business and delivery (7)

Encouraging bicycles and scooters (8)

Other (please specify) (9) _____

Q31 What are the challenges, if any, for people with physical disabilities to access transport services in your city?

Not accessible public transit (1)

Lack of paratransit (on-demand, door-to-door) services (2)

Affordability (3)

Driving inability (4)

Insufficient funding (5)

Noncompliant infrastructure (streets, sidewalks, crosswalks, curb ramps, crossing signals, street parking) (6)

Other (please specify) (7) _____

Q32 Is there any skim undergoing to facilitate transportation needs for people with physical disabilities?

Yes (1)

No (2)

Q33 Would you please elaborate about the skim?

_____

Q34 From which of these innovations would your current transportation system benefit the most? (select all that apply)

Introducing autonomous vehicles (1)

Low cost on demand TNC services to replace public transit in low-density areas (2)

Sharing vehicles among multiple services (3)

Online trip-plan share platform to find travel mates and ride together (4)

Pick up drop off services integrated with Public Transit network (5)

Reducing roadway capacity in low demand areas (6)

Creating local business districts to bring service opportunities close to the community (7)

Promoting local tourist attractions (8)

Encouraging work from home (9)

Other (please specify) (10) _____

Q35 If you pick one solution to meet the current transportation needs of the people of your city, what would you implement?

_____

_____

Q36 Are there any ongoing transportation project in your city?

Yes (1)

No (2)

Q37 What type of work it is?

Maintenance (1)

Construction (2)

Other (Please specify) (3) _____

Q38 What are the main challenges to implement transportation projects in your city? (select all that apply)

Access to federal funds (1)

Access to state funds (2)

Local match funds (3)

Lack of citizens involvement (4)

Lack of business involvement (5)

Lack of staff (6)

Lack of technical capability (7)

Lack of technology (8)

Lack of time (9)

Rightsizing the projects (10)

Demand projection difficulties (11)

Other (please specify) (12) _____

Q39 What is the major source of financing transport projects in your city?

Federal fund (1)

State fund (2)

Local fund (3)

Farebox (4)

Donation (5)

Private finance (6)

Other (please specify) (7) _____

Q40 Do you think any other financing strategy would be more beneficial? (specify if any)

_____

Q41 On average, how much money is spent approximately on transport infrastructure management each year in your city?

$ (1) _____

I don't know (2)

Q42 Based on which of the followings are transportation investment decisions made in your city?

Accessibility for all (1)

Community Vitality (2)

Congestion mitigation (3)

Cost effectiveness/ Return on investment (4)

Economic development (5)

Environmental impacts (6)

Favor disadvantaged people (7)

Integration with existing or planned land use (8)

Local priorities (9)

Promote driving (10)

Promote nonmotorized travel (11)

Promote transit (12)

Safety (13)

Other (please specify) (14) _____

Q43 What is the broadband coverage in your city? (Mention in % population under broadband coverage/ I don't know)

% population under broadband coverage (1)

_____

I don't know (2)

Q44 What is the mobile broadband/ LTE coverage in your city? (Mention in % population using mobile broadband/ LTE)

% of population under mobile broadband / LTE (1)

_____

I don't know (2)

Q45 How would you rate the community engagement in project decision making in your city?

Residents participate in decision making (1)	○ Strongly disagree (1)	○ Somewhat disagree (2)	○ Neither agree nor disagree (3)	○ Somewhat agree (4)	○ Strongly agree (5)
Representative of the residents participate in decision making (2)	○ Strongly disagree (1)	○ Somewhat disagree (2)	○ Neither agree nor disagree (3)	○ Somewhat agree (4)	○ Strongly agree (5)

Q46 Please write down any comment about any specific characteristics specific to your city that makes transportation in your city challenging.

_____

_____

_____

Q47 Please write down any comment or suggestion about this survey.

_____

_____

_____