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Does California High-Speed Rail Promote Accessibility for Station Cities?: Case Study of Fresno and Merced

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CSUTC California State University Transportation Consortium

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16. Abstract
California High-Speed Rail (CHSR) will largely change transportation cost across the state after it starts operating. Past studies show that only Fresno and Merced among station cities in the Central Valley would attract more future activities with the CHSR. The establishment of active CHSR also implies a new daily living sphere for all the station cities, and, therefore, accessibility to work and residential amenities should be reviewed to inform planners of future land-use and transportation developments. A research framework has been developed better to understand the impact of CHSR on job and amenity accessibility by driving, transit, and walking in Fresno and Merced. The results show the opportunity cost of accessibility for using CHSR for a 25-minute ride from Fresno to Merced and vice versa. The study then compares the original accessibility reached in the home city within 45 minutes and the accessibility reached from the station in the other city within the remaining time after arriving at the station from home. A t-test was also used to examine whether the newly accessible jobs and amenities are significantly better with the CHSR. Finally, these results were mapped in contours showing equal accessibility before and after the start of CHSR operation for all blog groups in the two cities. This study not only adds to the literature on the impact of high-speed-rails on accessibility to jobs and amenities, but also contributes to the practice of public transit and car-sharing for better accessibility by providing planning information through the mapping of the results.

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High-speed rail (HSR) provides more frequent service, lower cost, easier station access, greater reliability, and increased safety, and therefore has been regarded as a more effective transportation mode as compared to aviation for distances of up to 425 miles/700 km (Levinson, 2012; Sands, 1993; Sanuki, 1979). California is currently building a high-speed rail system (CHSR), which will run from San Francisco to Los Angeles in 3 hours and will extend to Sacramento and San Diego, totally 800 miles with 24 stations (CHSR website, 2023).

A city with a HSR station is likely to have higher growth rates of population, employment, and land use (Sands, 1993). HSR would also increase mobility and accessibility and therefore would change the physical landscape and economies around station cities (Garmendia et al., 2012; Levinson, 2012; Geng et al., 2015; Loukaitou-Sideris, 2013). A station city would not only confront the challenge of increased demand, but would also have to reassess accessibility to urban opportunities for a new daily living sphere (i.e., activities of daily life). Unfortunately, to date, there are no empirical studies on CHSR's effects on accessibility to jobs and amenities for valley cities and, therefore, is needed.

With this purpose in mind, this study examines how the CHSR would affect accessibility to jobs, schools, and parks by driving, transit, and walking for Fresno and Merced. A new analytic framework is proposed to examine the CHSR's effects on accessibility and to compare its effects between the two station cities, using four perspectives: opportunity costs, conditions for equal accessibility, statistical analysis, and contour mapping. We only discuss the results for the case of Fresno because the analysis involves too many results to cover all.

The results of the 25- and 45-minute accessibilities indicate that one can easily access most opportunities in the city. As a result, the CHSR does not seem to matter in terms of accessibility in Fresno if driving is the only mode considered in the city. The results also indicate that both transportation modes are inefficient in Fresno.

The analysis of opportunity costs for transit and walking (the 25-minute accessibility) implies that residents living west of Highway 99 and the first ring outside of downtown are potential "winners" of the CHSR because they have lower accessibility as compared to other residents.

The results of the 45-minute accessibility (the reference) by transit and walking in Fresno show that better job accessibility clusters in the downtown area, River Park, and Clovis; better school accessibility clusters around the city core; and better park accessibility clusters in the outskirts. The results of the optional (the 25-minute) accessibility by driving, transit, and walking in Merced through the CHSR simply show that the CHSR would benefit those residents who live closer to the Fresno station. The difference between the reference and optional accessibility suggests that the winners of the CHSR are those residents living west of Highway 99. This location is particularly suitable for those people who are young and focused on work, and therefore, the city can implement the idea of high-density housing there to promote economic equality and environmental sustainability.

The new accessibility by transit and walking suggests marginal improvement in the first ring outside downtown. Nevertheless, this increase is small. The statistical analysis indicates the winners of the CHSR project. The spatial pattern of these winners is similar to the results of the reference accessibility, implying that the CHSR does not change the pattern of winners in terms of accessibility in Fresno.

Finally, the contour mapping of the reference (the 45 minutes) and new accessibility provide information for identifying the locations with the same level of accessibility in both cities. These maps are useful for comparisons especially when a resident considers moving from one station city to the other.

The proposed analytic framework can be used not only in Fresno and Merced but also any other station cities to evaluate how the CHSR affects their accessibility. This study adds to the literature on accessibility and contributes to the practice of active transportation and compact development policies for sustainability.

1. Introduction

1.1 Background

High-speed rail (HSR) can be defined as a system operating daily at speeds of 150 mph/240 kmph and above, and it is usually used to improve intercity transportation by reducing travel time (Sands, 1993). HSR provides more frequent service, lower cost, easier station access, greater reliability, and increased safety, and therefore, it has been regarded as a more effective transportation mode as compared to aviation for distances of up to 425 miles/700 km (Levinson, 2012; Sands, 1993; Sanuki, 1979). Many countries have built their own HSR systems, such as Japan (Shinkansen), France (TGV), Germany (ICE), Taiwan (THSR), China (CRH), and South Korea (KTX) (Garmendia et al., 2012; Sands, 1993). California is also building a high-speed rail system (CHSR), which will run from San Francisco to Los Angeles in 3 hours and will extend to Sacramento and San Diego, totally 800 miles with 24 stations (CHSR website, 2023). The CHSR will change the current regional and urban structure across the state. (See Figure 1.)

Past studies have analyzed the effect of HSR on future developments along the rail routes at various spatial levels. On the one hand, at the regional level, a major concern of HSR is whether it would result in the concentration or dispersal of population and economic activities across the state (Garmendia et al., 2012; Hall, 2009; Sands, 1993). New developments could be inconsistent, depending upon the economic strength of station cities, and therefore could enlarge the disparity between large metropolitan areas and small local cities. Wang et al. (2017) used a gravity model to simulate future developments and found that the CHSR would eventually enhance the polarization of the two mega-cities in California: San Francisco and Los Angeles. In the Central Valley, their research shows that only Fresno and Merced would attract future activities from other station cities and grow because they have comparatively stronger economies compared to other Valley cities.

On the other hand, at the urban level, a city with a HSR station is likely to have higher growth rates of population, employment, and land use (Sands, 1993). HSR increases mobility and accessibility and therefore would change the physical landscape and economies around station cities (Garmendia et al., 2012; Levinson, 2012; Geng et al., 2015; Loukaitou-Sideris, 2013). A station city would not only confront the challenge of change and increase in demand, but also have to review and assess accessibility to urban opportunities (e.g., jobs and amenities) for a new daily living sphere. The CHSR would shape a new daily living sphere for each station city and inevitably result in winners and losers within the city. Unfortunately, there are no empirical studies to date on CHSR's impact on accessibility to jobs and amenities for Valley residents.

Figure 1. CHSR Statewide System

Source: CHSR Authority

1.2 Motivation and Objectives

Mobility and accessibility have been widely regarded as important elements in the consideration of social and economic equality. Wand and Chen (2018) applied a GIS-based cumulative opportunity approach to measure the accessibility to an array of urban opportunities (jobs, physical activities and dining, social interactions, and public facilities) by driving, transit, and cycling for Fresno. The two-sample t-test was also used to examine whether there is a significant difference between the two ends respectively in income, property value, school enrollment, vehicle ownership, race, and age. Along this line, Wang (2019) developed an optimization modeling framework to address the problem of unequally distributed multi-use paths in Fresno by allocating future transportation investments at the optimal locations.

The CHSR would change mobility and accessibility of a station city because residents in a station city could access not only jobs and amenities in their own city but also those in other station cities throughout the CHSR system. Therefore, it is vital to (1) measure accessibility with the consideration of the CHSR for a new daily living sphere and to (2) identify winners and losers through a "before and after" comparison. Some areas in a station city would have better job and amenity accessibility, and some would not. These results would provide transportation planning information for better connecting to local transportation networks (e.g., sidewalk, public transit, bike- or car-sharing). This, in turn, would improve mobility and accessibility and potentially reduce inequality. Such a research framework is needed for station cities to promote overall accessibility and equal developments.

With this purpose in mind, Fresno and Merced are considered better to understand the interaction between a larger city and a smaller city when a change in the daily living sphere is made by the CHSR. Land-use and transportation planning require an understanding of the CHSR's impact on accessibility to jobs and amenities (schools and parks). Therefore, this study is needed to provide a research framework to evaluate comprehensively accessibility with the consideration of CHSR. The objectives are as follows:

- To calculate the impact CHSR has on accessibility to jobs and amenities in Fresno and Merced
- To compare job and amenity accessibility before and after the operation of the CHSR at the block group level for the two cities
- To identify where the CHSR would create better job and amenity accessibility with a new daily living sphere and where the CHSR would not
- To provide transportation planning information for improving overall accessibility and promoting equal developments through better connection to local transpiration networks

2. Methods and Data

2.1 Calculation of Accessibility

The cumulative-opportunity approach, a location-based accessibility measure, has been widely used in accessibility studies (Castiglione et al., 2006; Martens and Golub, 2011), including four Fresno State Transportation Institute (FSTI) funded research projects from 2018 to 2021. In this study, it is used to compute job and amenity accessibility through multi-transportation modes for each of the census block group (BG) in Fresno and Merced. This accounts for the total number/area of opportunities (jobs, schools, and parks) that a resident in a given BG can reach by a combination of walking, transit, car, and CHSR. For instance, within a 45-minute commuting time, job accessibility for a resident living in Fresno can be computed by counting the number of jobs reachable in Fresno from the home BG by 45 minutes' walking, transit, or driving, using the Network Analyst package in ArcGIS. In this case, the equation for job accessibility by a transportation mode can be formulated as:

$$A_i = O_i + \sum_{j=1}^{J} B_j O_j \quad (1)$$

where A_i is the job accessibility (high-, medium-, and low-wage jobs) for BG_i; O_i is the number of jobs in BG_i reachable by a transportation mode; B_j is a binary parameter, = 1 if the centroid of BG_j is within the 45-minute commuting buffer, = 0 otherwise; O_j is the number of jobs in BG_j. Similar approaches will apply for amenity accessibility (schools and parks).

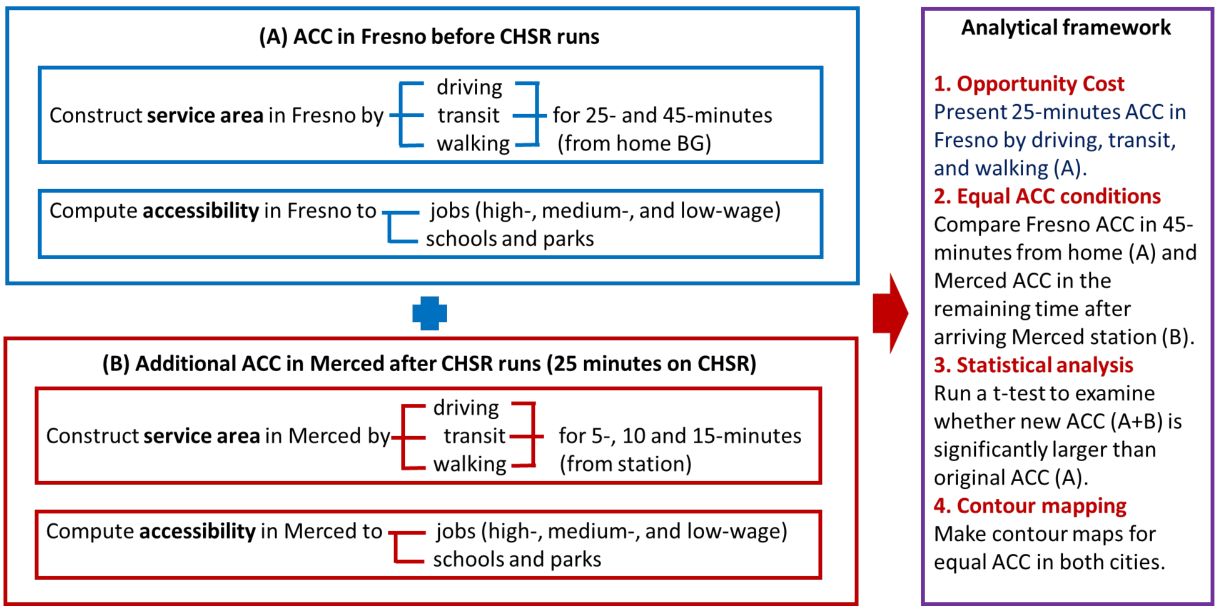
Using this approach, this study first computes accessibility to jobs, schools, and parks from home BG by 45 and 25 minutes of driving, transit, and walking for Fresno and Merced respectively. The 45-minute travel time is considered as the maximum time that residents are willing to travel to work or to activities of interest in both cities, while the 25-minute travel time is used to represent the opportunity cost of using the CHSR under the assumption that traveling from Fresno to Merced on the CHSR is 25 minutes.

Then another set of calculations is used to compute accessibility to jobs, schools, and parks from the HSR station by 15, 10, and 5 minutes. These calculations are performed for driving, transit, and walking in both Fresno and Merced. These calculations are prepared for further analysis and comparison. For instance, a Fresno resident will have two options after the CHSR runs: work in Fresno or work in Merced. With the calculations, one can compare the number of jobs reachable within a 45-minute travel time in Fresno to that reachable within the remaining time after arriving at the Merced HSR station from home.

2.2 Research Framework

Accessibility usually refers to how easily one can reach an urban opportunity in a city. With new technologies in GIS and spatial data, it has become practical to measure and analyze accessibility for a single city, as stated in the previous section. Nevertheless, analyzing accessibility becomes more complicated when traveling in multiple cities is possible. Such analysis not only involves many combinations of accessibility in different cities, but also various traveling preferences. Moreover, a substantial transportation project would result in a big change in accessibility, such as HSR. In this case, successful future developments largely depend on understanding of the impact of HSR on accessibility and the ability to identify winners and losers to inform decision makers. With these two concerns in mind, this study develops and proposes a research framework to analyze the accessibly calculations mentioned in the previous section, as presented in Figure 2.

Figure 2. Research Framework from the Perspective of Fresno Residents



2.2.1 Opportunity cost

The first perspective which can be used to understand the value of the accessibility alternative is the concept of opportunity cost. As mentioned earlier (the calculation (A) in Figure 2), this study computes how many jobs and amenities one can access from the home BG by driving, transit, and walking within 25 minutes of one's home city (Fresno or Merced). If one supposes the commuting time on the CHSR from Fresno to Merced is 25 minutes, the computed accessibility can be seen as the opportunity cost of using the CHSR for both cities.

Note that the result concerns two factors: transportation network and land-use allocation. One who lives at a location where better transportation is invested and more amenities are allocated would have better accessibility. In other words, the opportunity cost of using the CHSR would be higher, and therefore, residents living at that location would have less motivation to use it. The opportunity cost of using the CHSR will be mapped for both cities.

2.2.2 Conditions for equal accessibility

The second perspective is to compare the accessibility reachable in the home station city to that reachable in the other station city though CHSR (i.e., the calculation (B) in Figure 2). A 45-minute travel time is selected for this comparison. One of the reasons is that 45 minutes as the maximum travel time would still be acceptable for most people living in the Central Valley. Another reason is that a larger travel time can allow for more variations in accessibility for a greater number of locations in both cities.

If one supposes the driving time from home to the HSR station is X minutes, the remaining time to access jobs and amenities in the other station city will be (45-25-X) minutes for the alternative of using the CHSR. In other words, one would have 5, 10, or 15 minutes to reach jobs and amenities by driving (car-sharing), transit, or walking in the other city. To compare two alternatives, we can simply deduct the computed accessibility reachable within (20-X)-minutes in the other city (the calculation (B) in Figure 2) from that reachable within 45 minutes in the own city (the calculation (A) in Figure 2). A location with a positive result implies that residents living at that location would be able to access more opportunities in another city using the CHSR.

2.2.3 Statistical analysis

The third perspective is to conduct a statistical analysis. Besides the opportunities (jobs and amenities) reachable in the home station city, a resident will have additional opportunities to reach in the other station cities after the CHSR runs. Therefore, a new accessibility can be computed by adding the additional accessibility (i.e., the 5-, 10-, or 15-minute accessibility in the other station city) to the original accessibility (i.e., the 45-minute accessibility in the own city). In other words, the new accessibility is the sum of the calculations (A) and (B) in Figure 2. Then, a t-test can be used to examine whether the new accessibility is significantly larger than the original accessibility before the CHSR runs. The idea is that the original accessibility computed for all the BGs in a city is a distribution. The t-test is used to see whether the new value of accessibility is significantly larger than the average of old ones.

Thus, those locations where the new values are significantly larger imply they are the winners of this CHSR project, which means that the CHSR would advantage these locations for accessing more opportunities. The results will also show these advantaged locations in terms of jobs and in amenities, respectively. The advantaged locations in jobs might be more suitable for those who need to work, while those in amenities might be better for those who focus on family, education, and life quality. Those locations where the new values are insignificant imply that they are losers of this project, and therefore, there might be inequality issues to address. The mapping of these results would inform decision makers about future needs and corresponding planning.

2.2.4 Contour mapping

The last perspective which can be used better to understand the impact of CHSR on accessibility is the mapping of accessibility in contours before and after the CHSR runs. All the locations falling in the same contour represent the same level of accessibility. Residents in both cities can see where accessibility is the same—not only across the home station city, but also in the other station city. By looking at the contour map for new accessibility options, they can see not only whether their accessibility would significantly change, but also potential spots for relocation. These maps would also help planners allocate future jobs and amenities to satisfy needs and address inequality. Finally, these maps would be useful for improving walkability, promoting public transit, and building a car-sharing system around the station.

3. Results

This section only shows the results for Fresno because the accessibility analysis for both cities involves too many maps. Another reason is that this study aims to provide an analytic framework. The approach used to interpret Fresno results can also be applied for the case of Merced.

3.1 Opportunity Cost

The opportunity costs show how many opportunities one would miss within the home city if s/he takes the CHSR to access those same opportunities in the other station city with a 25-minute trip. The opportunity costs of driving in Fresno are presented in Figure 3. Overall, the accessibility to jobs (total and high wage), schools, and parks (one would give up) by driving is all good with slight difference. As compared to job accessibility, school accessibility is a bit worse because fewer schools are located in the outskirts, while park accessibility is a bit better because more parks are in the outskirts. It is worth noting that the opportunity costs for the CHSR would be high if driving is the only transportation mode considered in the Valley.

Figure 4 presents the opportunity costs of taking transit for 25 minutes for Fresno. The results show more variations as compared to driving. Since transit is not considered as an efficient mode in Fresno (Chen and Wang, 2020), the accessibility is more related to the allocation of land use. Therefore, jobs are mostly located downtown, in the River Park Shopping Center, and in Clovis. There are more schools located in the city core, while there are more parks located in the outskirts. The maps suggest that those residents living west of Highway 99 and in the first ring outside of downtown Fresno have lower opportunity costs for using the CHSR, and therefore, they might be potential winners of this transportation infrastructure. The opportunity costs of walking and taking transit in Fresno are similar because both are inefficient transportation modes (see Figure 5).

Figure 3. Opportunity Costs by Driving for Fresno

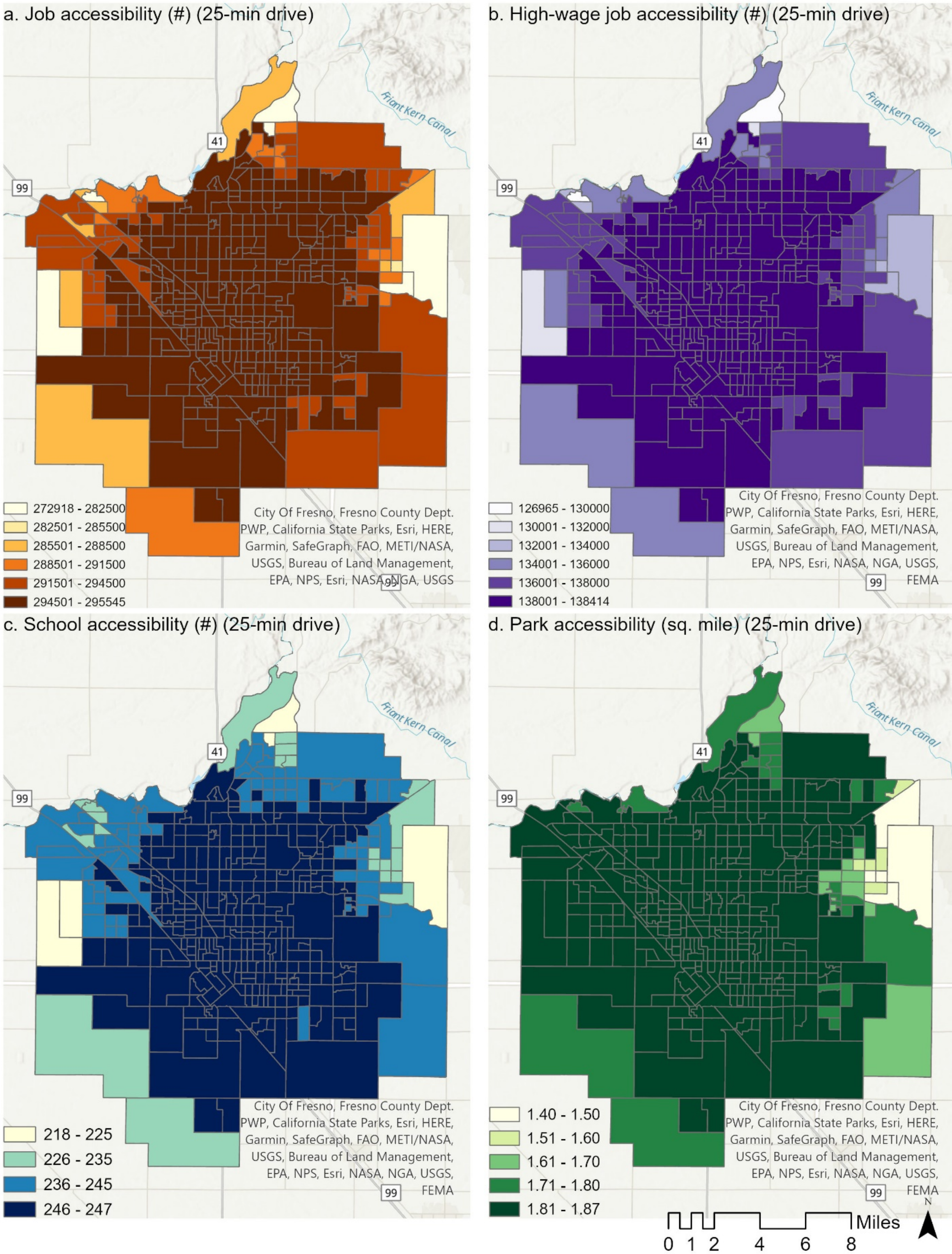


Figure 4. Opportunity Costs by Transit for Fresno

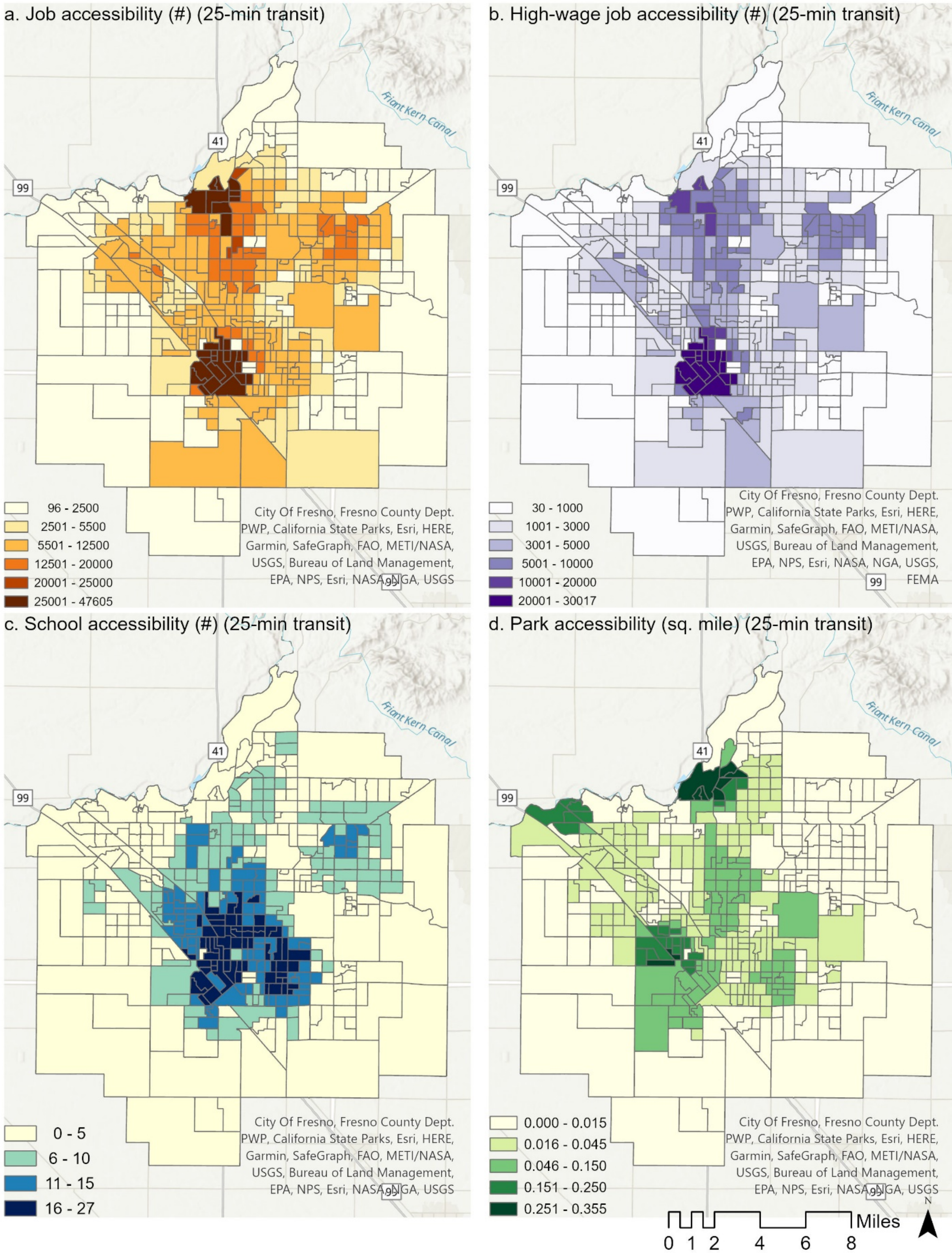
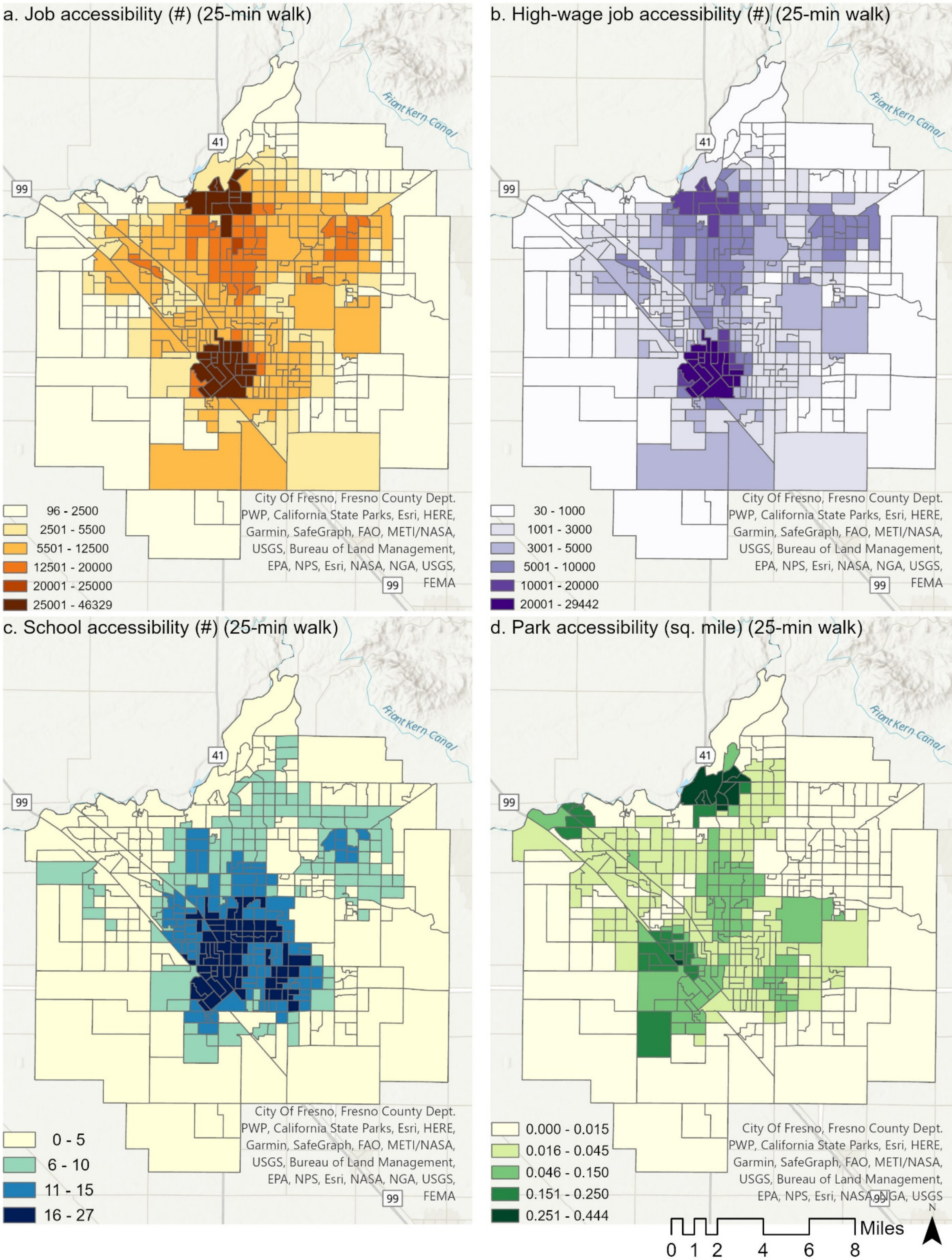


Figure 5. Opportunity Costs by Walking for Fresno



3.2 Conditions for Equal Accessibility

3.2.1 45-minute accessibility reference

A 45-minute traveling time is used to compute accessibility by driving, transit, and walking for Fresno and Merced as a reference. With a 45-minute drive in Fresno, one can reach all opportunities across the city with 295545 total jobs, 138414 high-wage jobs, 247 schools, and 1.87 square miles of park (not shown here). For the two slower modes (transit and walking), job accessibility shows three clusters (the downtown, River Park, and Clovis), school accessibility shows a single cluster around the city core, and park accessibility shows four clusters scattered in the downtown and outskirts. See Figure 6 and 7. These clusters also represent the winners of the original setting of land use and green transportation infrastructure (transit and walking) in Fresno.

Accessibility is essentially a result of two factors: land-use allocation and transportation investment. Similar to the analysis of the opportunity costs, the results here indicate that land-use allocation does not affect accessibility by driving but does affect accessibility by transit and walking. This is because transit and walking are both inefficient in Fresno as compared to driving. This is also why Fresno is a typical auto-oriented city, resulting in urban sprawl. It is worth noting that accessibility by walking is slightly better than by transit, with a 45-minute travel time, implying that walking might be more efficient than transit in Fresno.

Figure 6. Accessibility Reference by (45 Minutes) Transit for Fresno

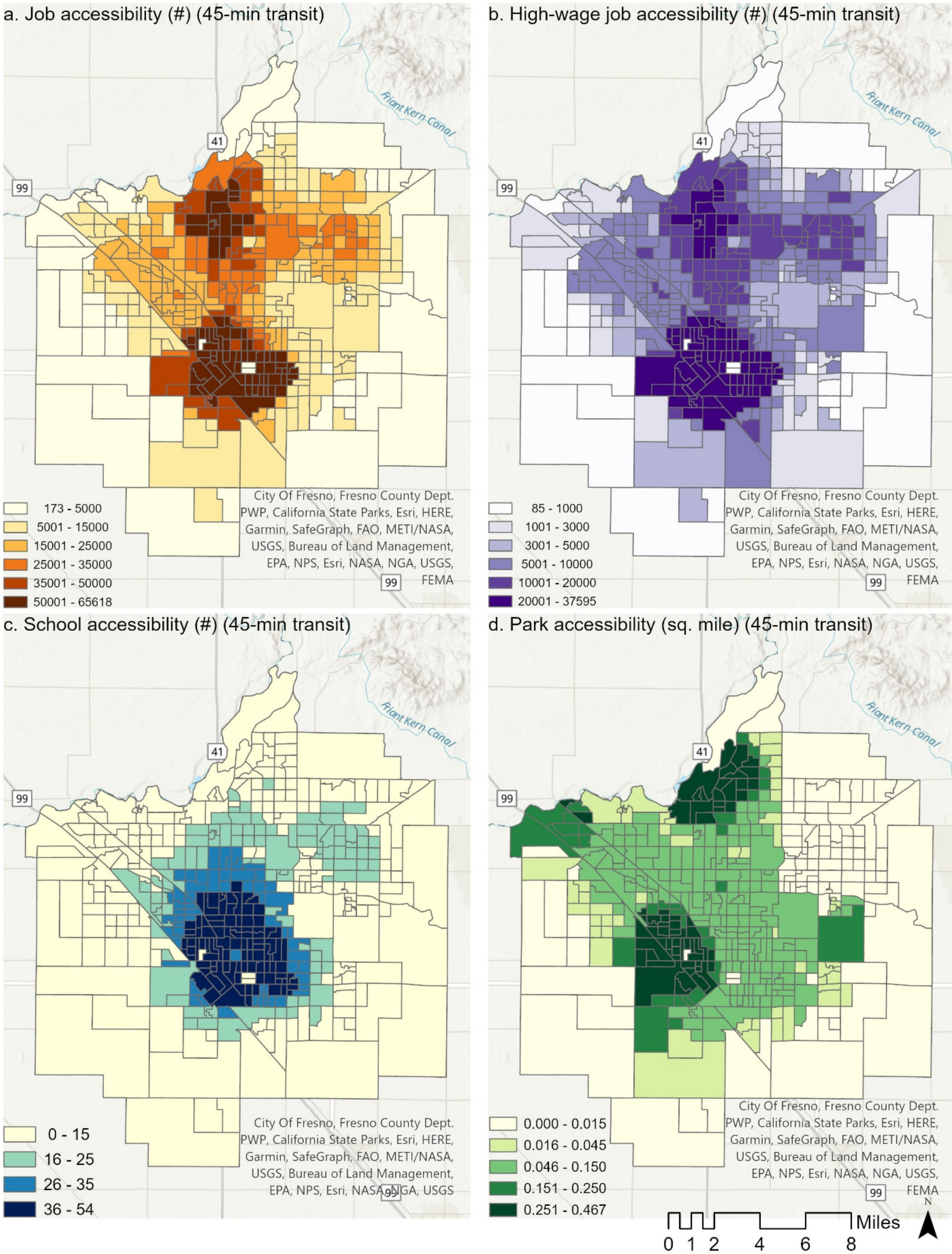
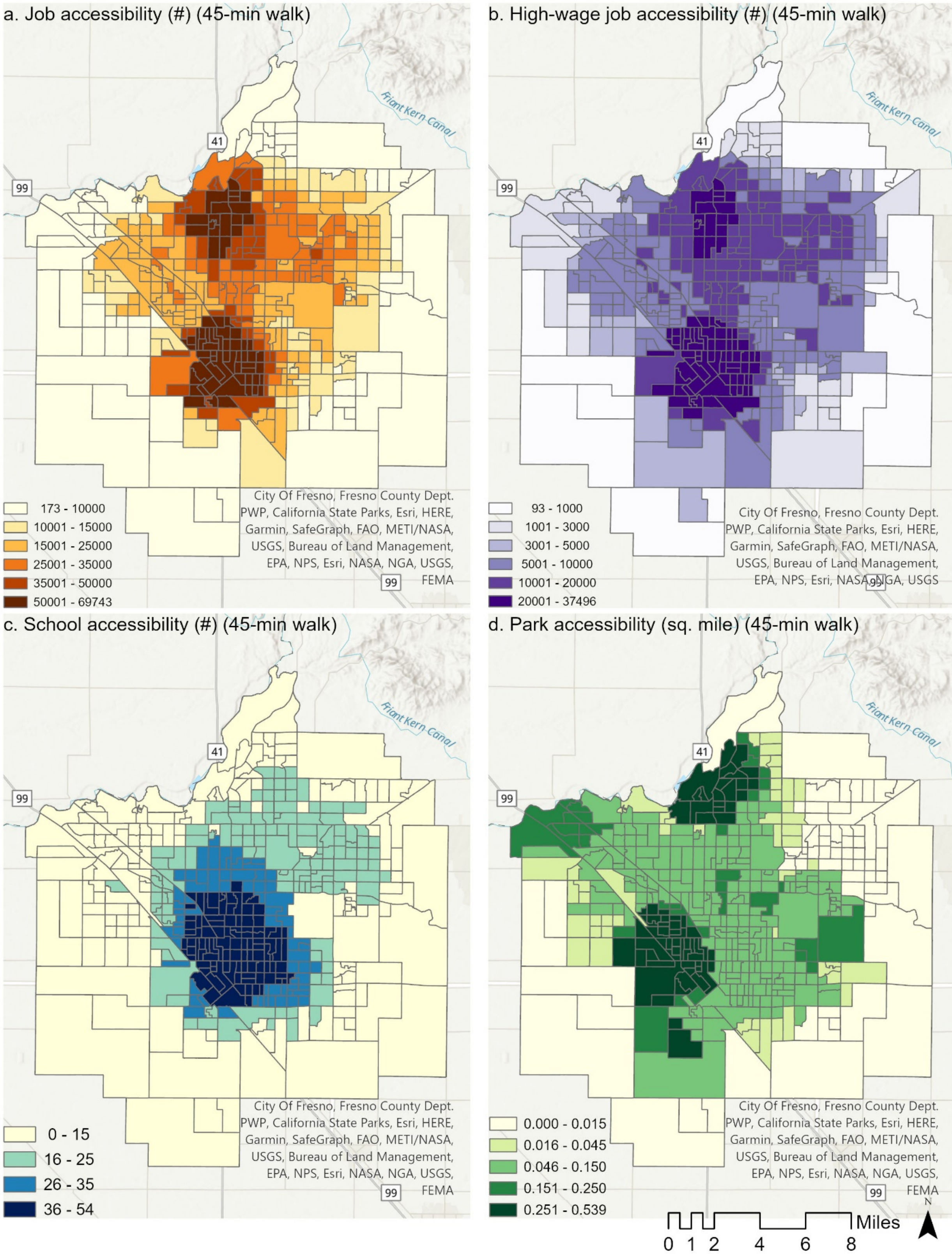


Figure 7. Accessibility Reference by (45 Minutes) Walking for Fresno



3.2.2 Optional accessibility through the CHSR

After the CHSR runs, Fresno residents would be able to access the opportunities in Merced. Such optional accessibility depends on where the resident lives. For instance, one would be able to access opportunities in Merced from the CHSR station by driving, transit, or walking for 15 minutes (45-5-25 = 15), if one lives within a 5 minutes' drive to the CHSR station in Fresno. This is under the assumption of 25-minute HSR travel time. For Fresno residents, we consider three travel times in Merced in this study: 5 (15 minutes' drive to the Fresno station), 10 (10 minutes' drive to the Fresno station), and 15 (5 minutes' drive to the Fresno station) minutes. The results are as presented in Figures 8-10.

Figures 8-10 compare a Fresno resident's access to opportunities in Merced via car, transit, and walking from the CHSR station. The results follow a 4-ring pattern for 5, 10, and 15-minute travel time respectively. Residents who live closer to the Fresno station would have more time to access opportunities in Merced after arriving at the Merced station. Therefore, the CHSR would benefit those Fresno residents who live closer to the CHSR station. Note that the residents living in the fourth ring will not benefit at all because they live more than 45 minutes away from opportunities in Merced. It is also worth noting that the optional park accessibility by transit and walking (see Figure 12 and 13) is much less than other opportunities, implying that parks are located far away from the Merced station.

Figure 8. Optional Accessibility by Driving in Merced for Fresno

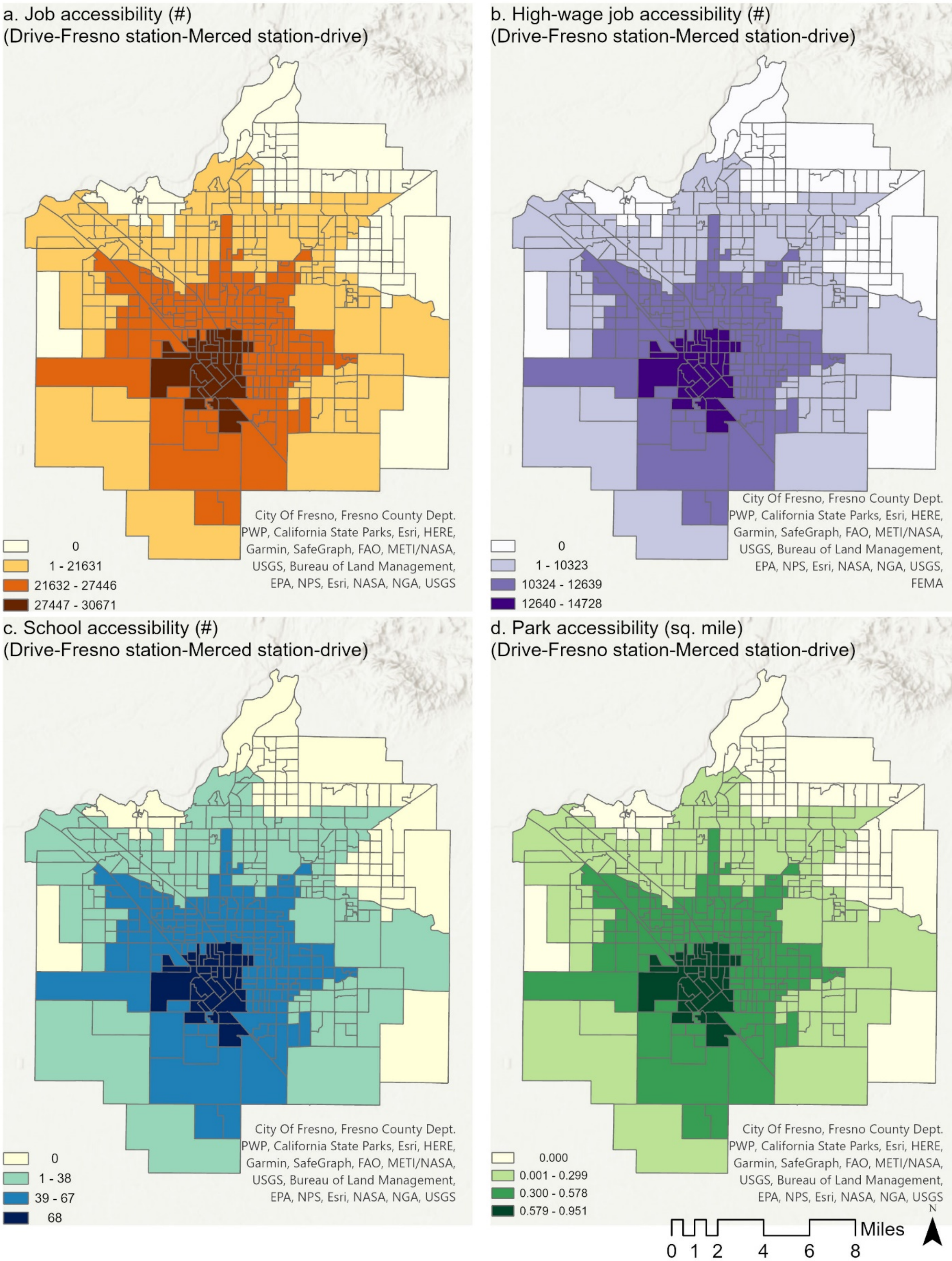


Figure 9. Optional Accessibility by Transit in Merced for Fresno

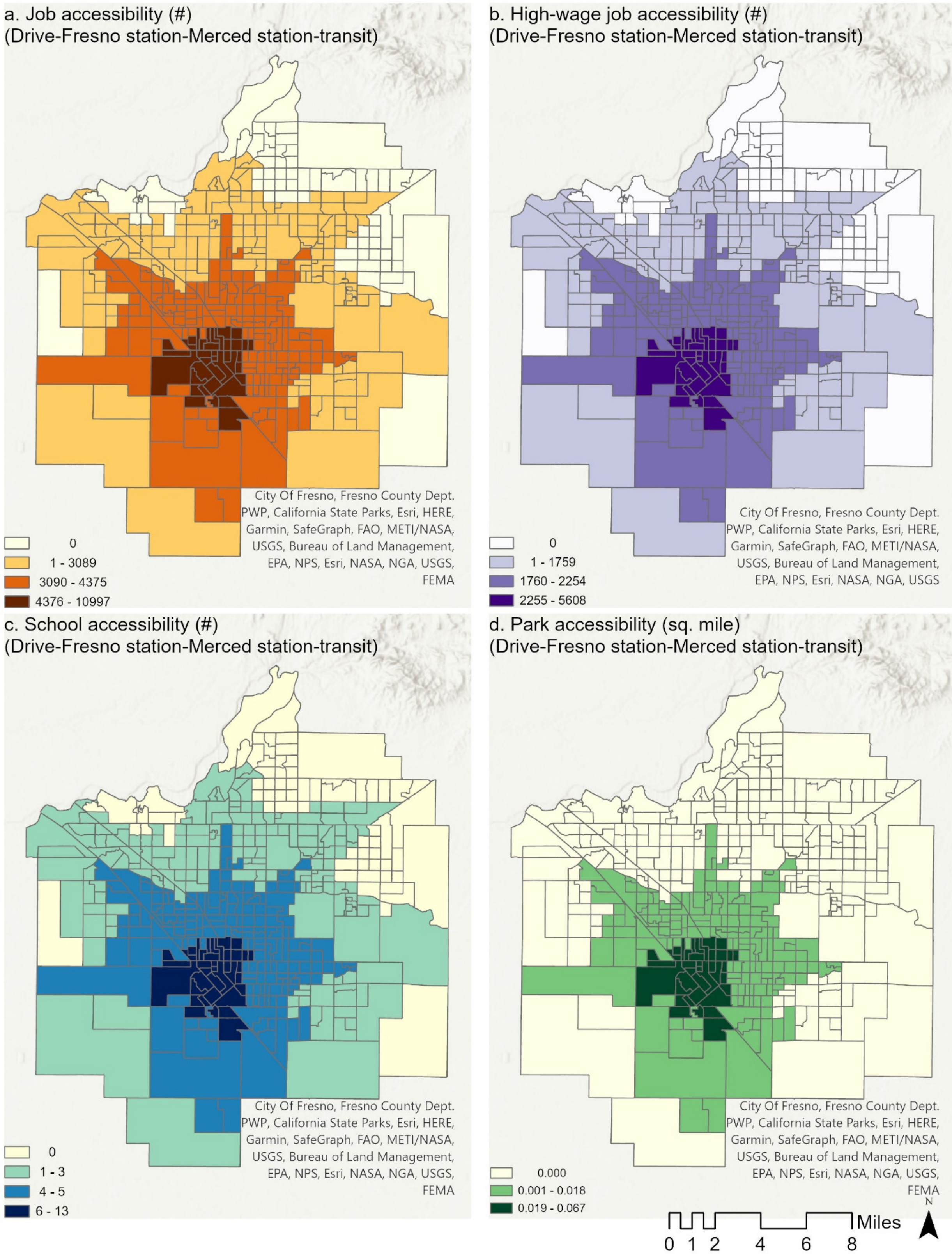
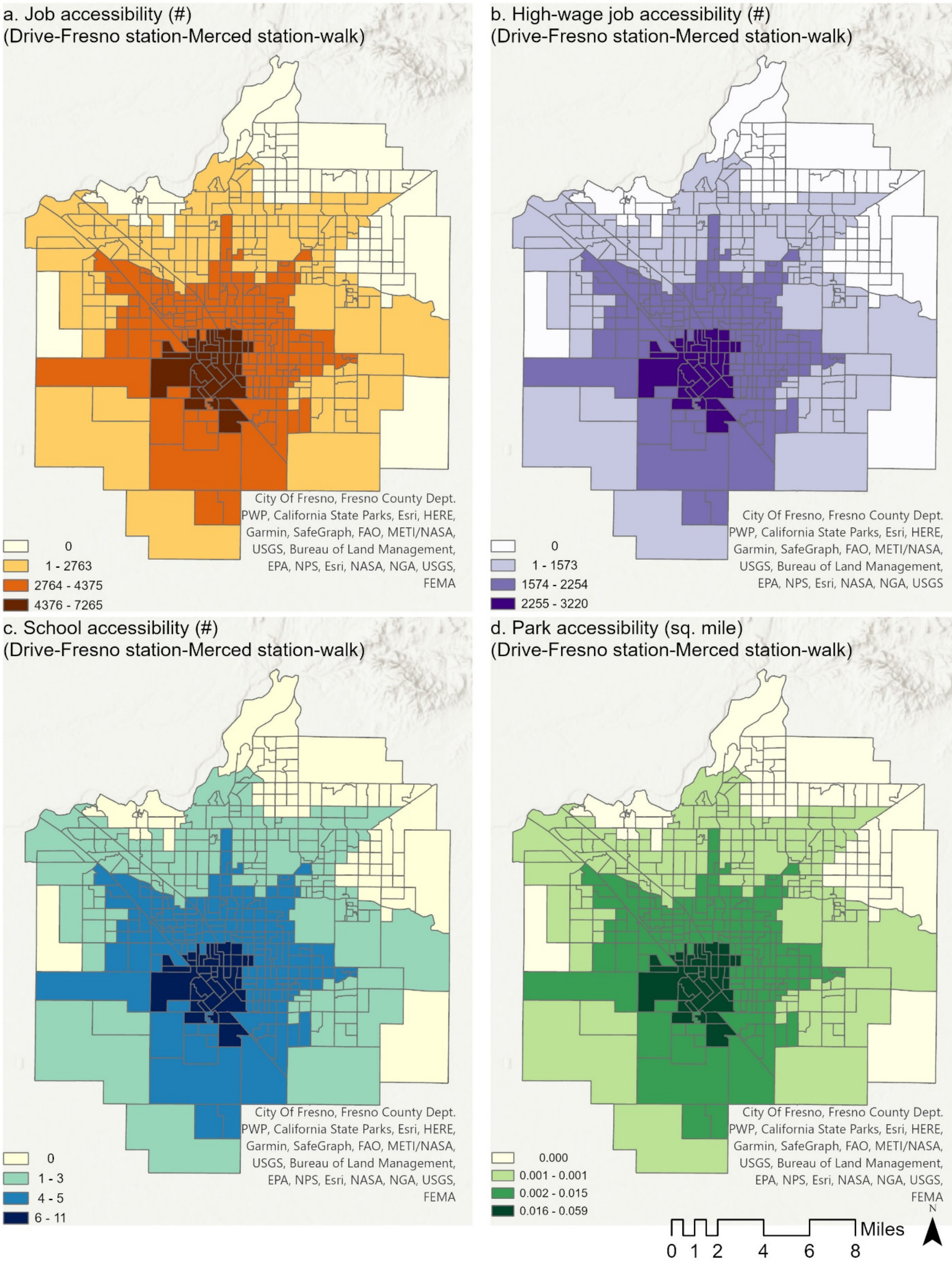


Figure 10. Optional Accessibility by Walking in Merced for Fresno



3.2.3 Difference between original and optional accessibility

Figures 11-13 show the difference (in %) between original (45-minute travel time) and optional accessibility by driving, transit, and walking for Fresno. From Figure 11, it is evident that the CHSR will not benefit any Fresno residents in terms of accessibility (all negative values) if driving is the only transportation mode considered. The results also show a larger negative difference in job accessibility than that in schools and parks, implying that Fresno has better job opportunities than Merced.

Nevertheless, the CHSR helps address accessibility inequality in Fresno. Figures 12 and 13 share a similar spatial pattern because transit and walking are both less efficient modes. The results show that residents in the much less developed areas (but not too far away from the Fresno station) could access more jobs and schools in Merced through the CHSR. The city of Fresno could enhance this benefit by improving the transportation connection from these locations to the CHSR station, using sidewalks, bikeways, and bus routes.

The results point out that these locations in Fresno not only lack job opportunities, but also schools and will not get much in Merced through the CHSR. Therefore, these locations are suitable for young people who do not yet have family and particularly focus on work. This also gives the city of Fresno a chance to develop high-density housing because these people need affordable housing more than space. All of these would together help promote a compact city which would be more environmentally sustainable and economically equal.

Figure 11. Difference Between Original and Optional Accessibility by Driving for Fresno

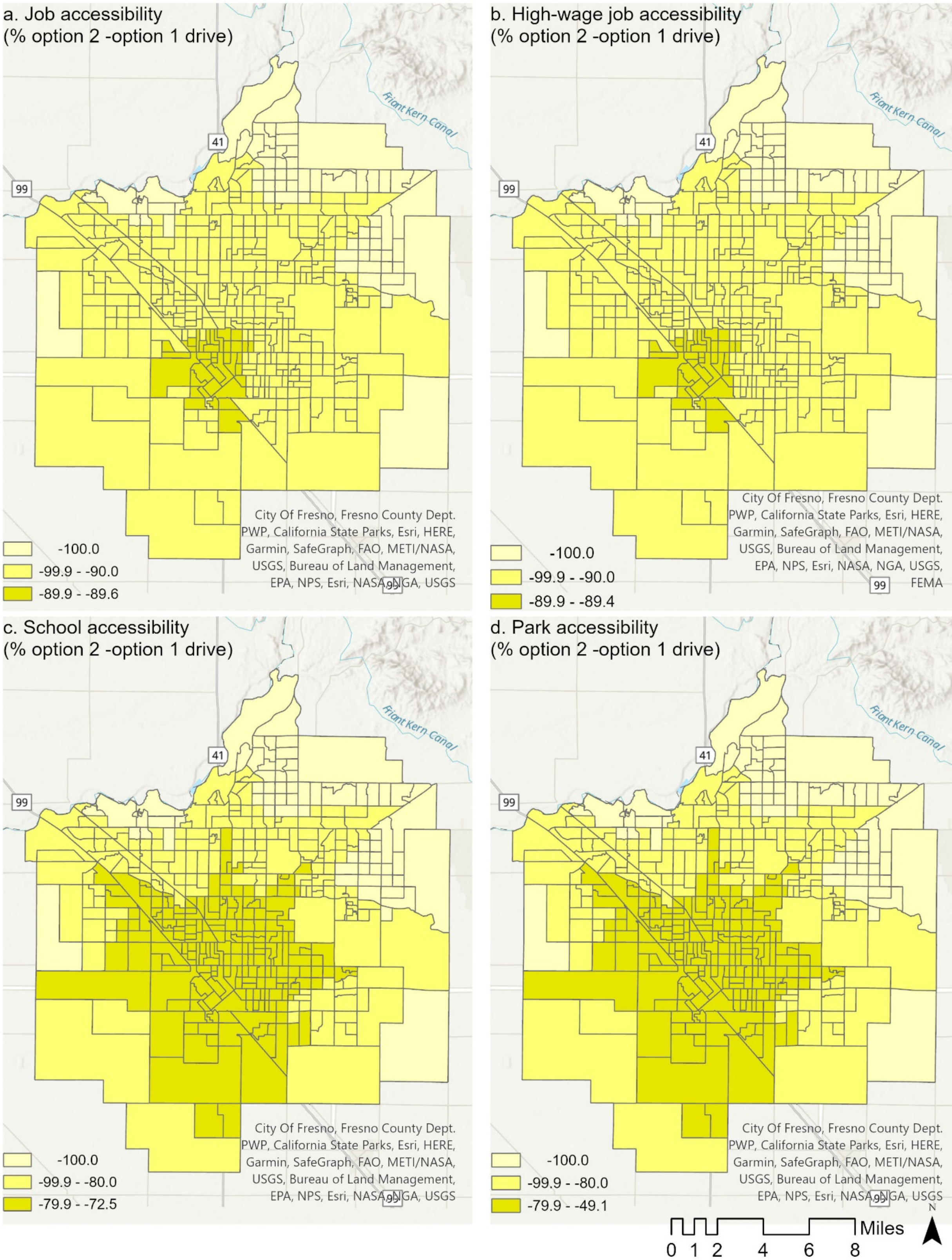


Figure 12. Difference Between Original and Optional Accessibility by Transit for Fresno

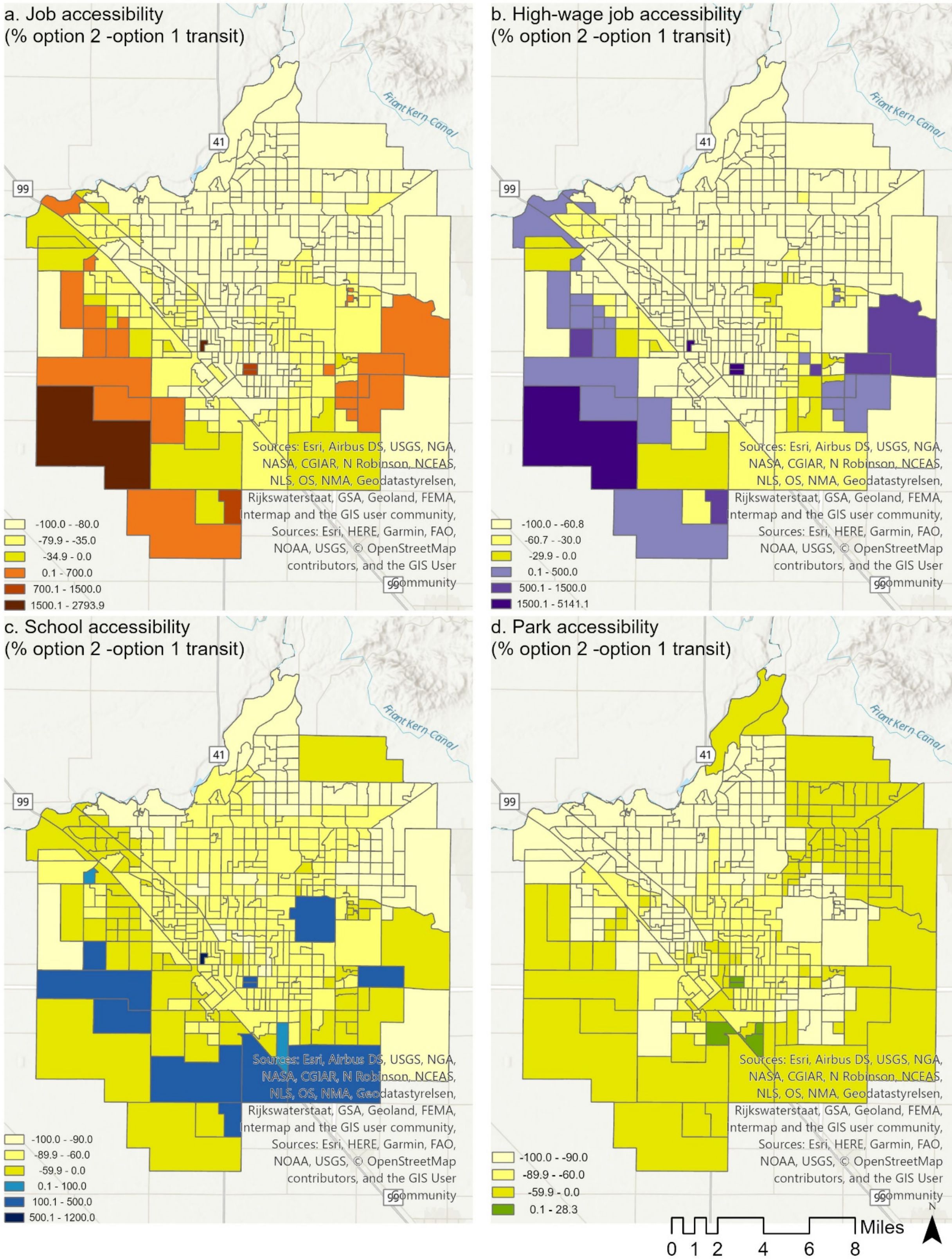
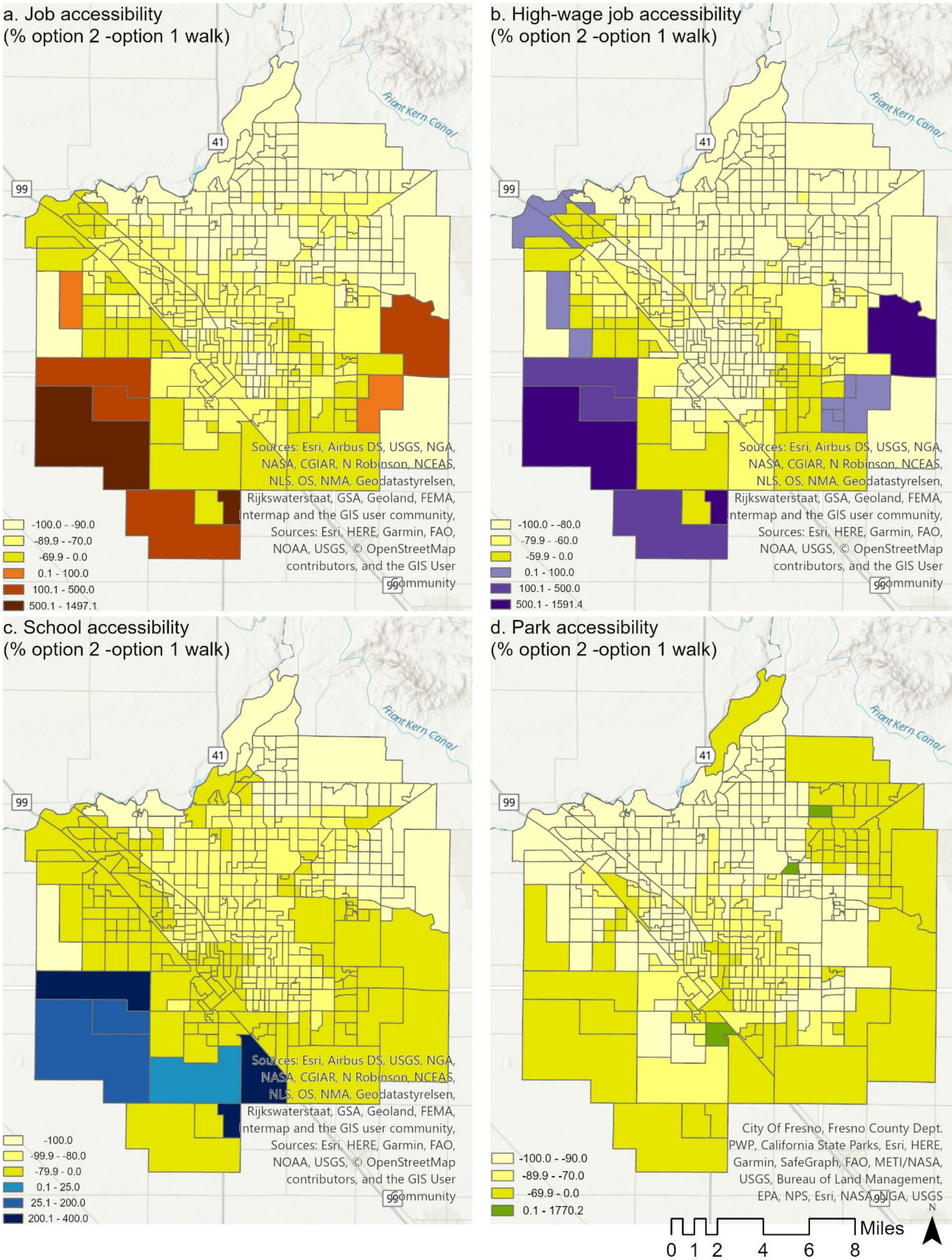


Figure 13. Difference Between Original and Optional Accessibility by Walking for Fresno



3.3 Statistical Analysis

3.3.1 New accessibility

New accessibility by driving, transit, and walking for Fresno is calculated by summing up the opportunities accessible in Fresno and Merced via the CHSR (see Figure 14-16). Figure 14 uses the original (45 minutes driving) accessibility as a base map and adds the optional accessibility to it. Because the original accessibility map has no variations (only a single value), Figure 14 shows the same spatial pattern as the optional accessibility by driving (Figure 8). Therefore, the CHSR would benefit the residents who live closer to the Fresno station.

For transit and walking, we use the same scales for mapping both the original and new accessibility. The same color on a map represents the same level of accessibility. Thus, we can easily compare the original accessibility maps to the new ones. When comparing Figures 6 and 15, the first ring outside of downtown Fresno has an increase in accessibility by transit after adding the optional accessibility to the original ones. This also applies to the new accessibility by walking (see Figures 7 and 16). These findings correspond to the analysis of opportunity costs, showing that the residents in the first ring outside downtown Fresno might be potential winners of the CHSR. It is also worth noting that these are only small increases, most likely because Fresno has better opportunities in the first place, as compared to Merced.

Figure 14. New Accessibility by Driving for Fresno

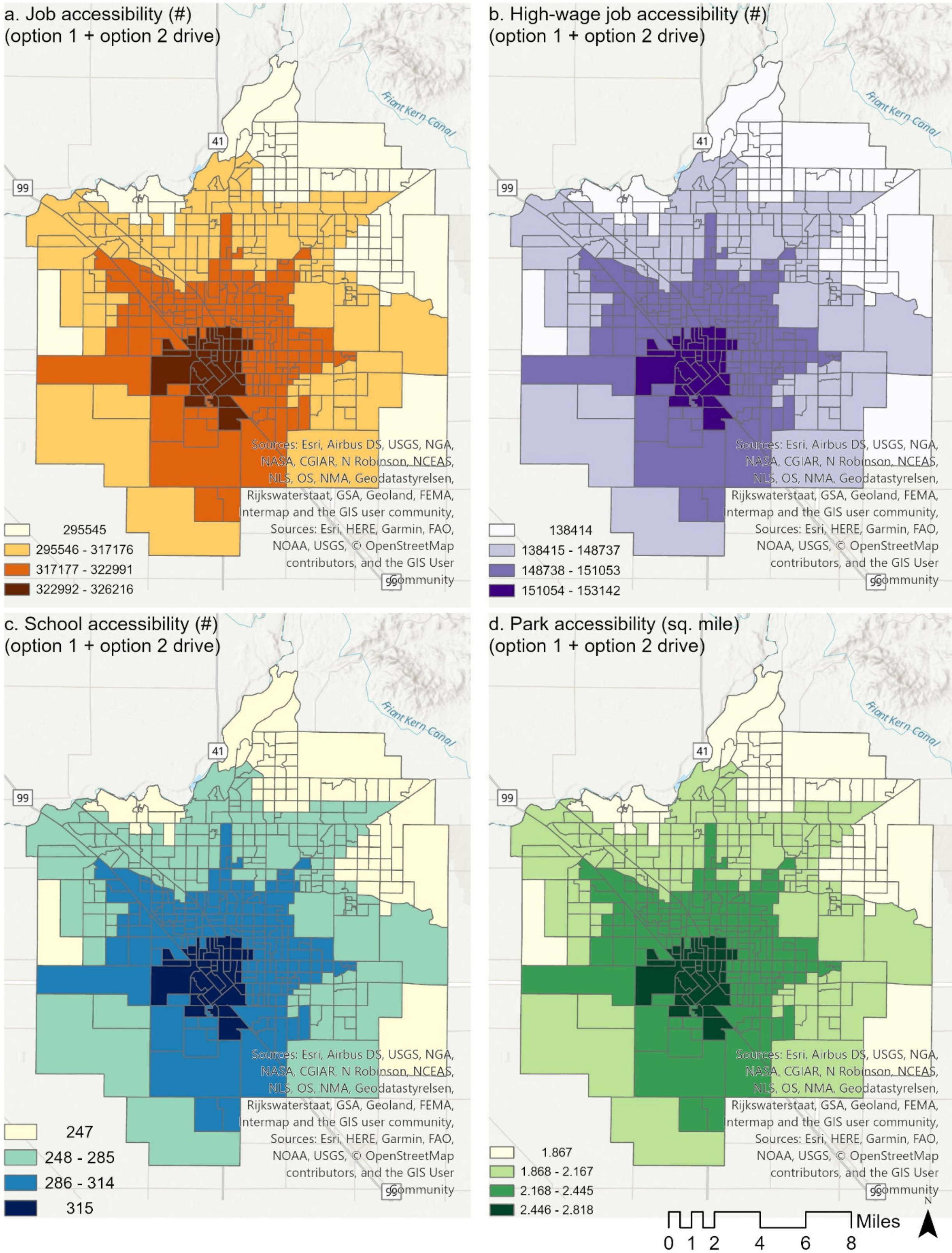


Figure 15. New Accessibility by Transit for Fresno

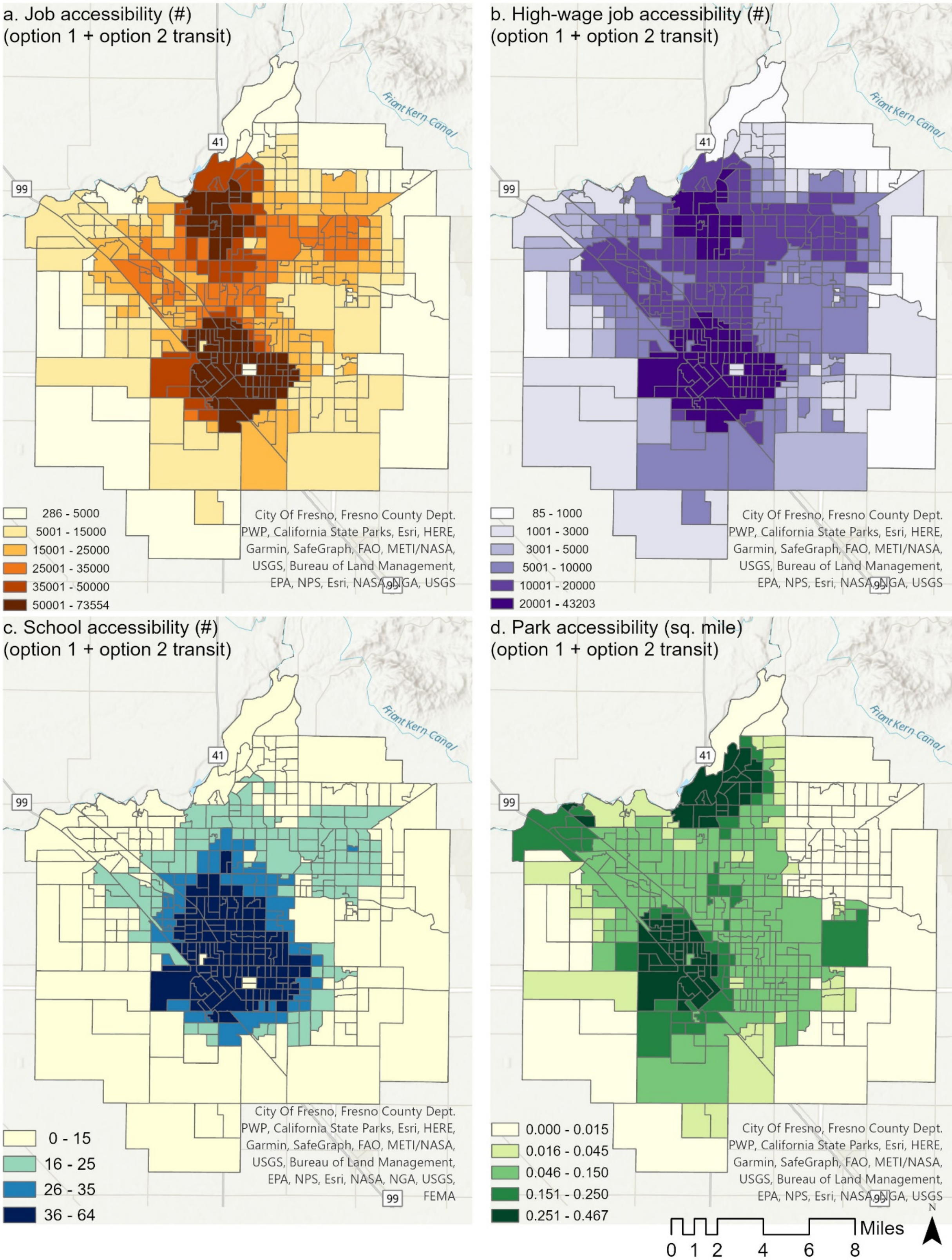
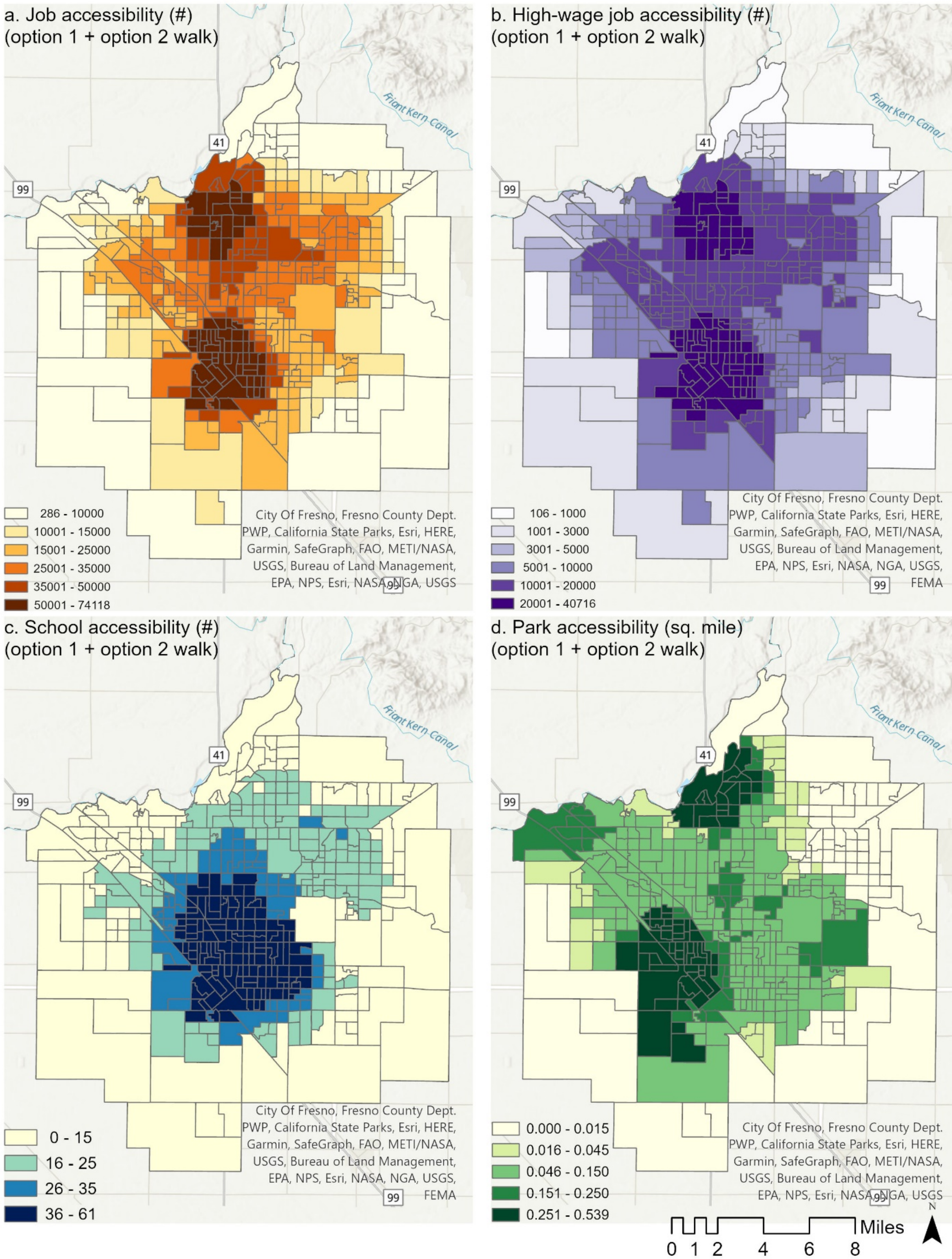


Figure 16. New Accessibility by Walking for Fresno



3.3.2 T-test results

The t-test is used to examine whether the new accessibility is significantly larger than the original ones. The original accessibility (Fresno opportunities accessible with a 45-minute travel time) across the city can be seen as a normal distribution according to the law of large numbers in statistics. Thus, we can compute the cumulative probability of a new accessibility value (the original accessibility in Fresno + the additional one in Merced through the CHSR), using the mean and standard deviation extracted from the distribution. Since the original accessibility by driving has only a single value across the city, it does not have a distribution. Therefore, we only run t-tests for the new accessibility by transit and walking (see Figures 17 and 18).

Figures 17 and 18 share similar spatial patterns because transit and walking are both inefficient modes in Fresno. The new job accessibility (total and high-wage) by transit and walking in downtown Fresno and the River Park Shopping Center is significantly larger than the average of the original ones, implying the winners of not only the original built-environmental setting, but also the CHSR. Again, this is more related to the allocation of jobs (through land-use planning) because transit and walking are not efficient modes.

In terms of schools and parks, the new accessibility by transit and walking does not change the original spatial pattern of better school accessibility clustering around the city core and better park accessibility being scattered in the outskirts. Figures 17 and 18 point out these winners of better accessibility to amenities (schools and parks). In a word, the CHSR does not change the pattern of original winners who use transit and walking, and it does not matter if one considers driving as the means to access opportunities.

Figure 17. T-test for the New Accessibility by Driving for Fresno

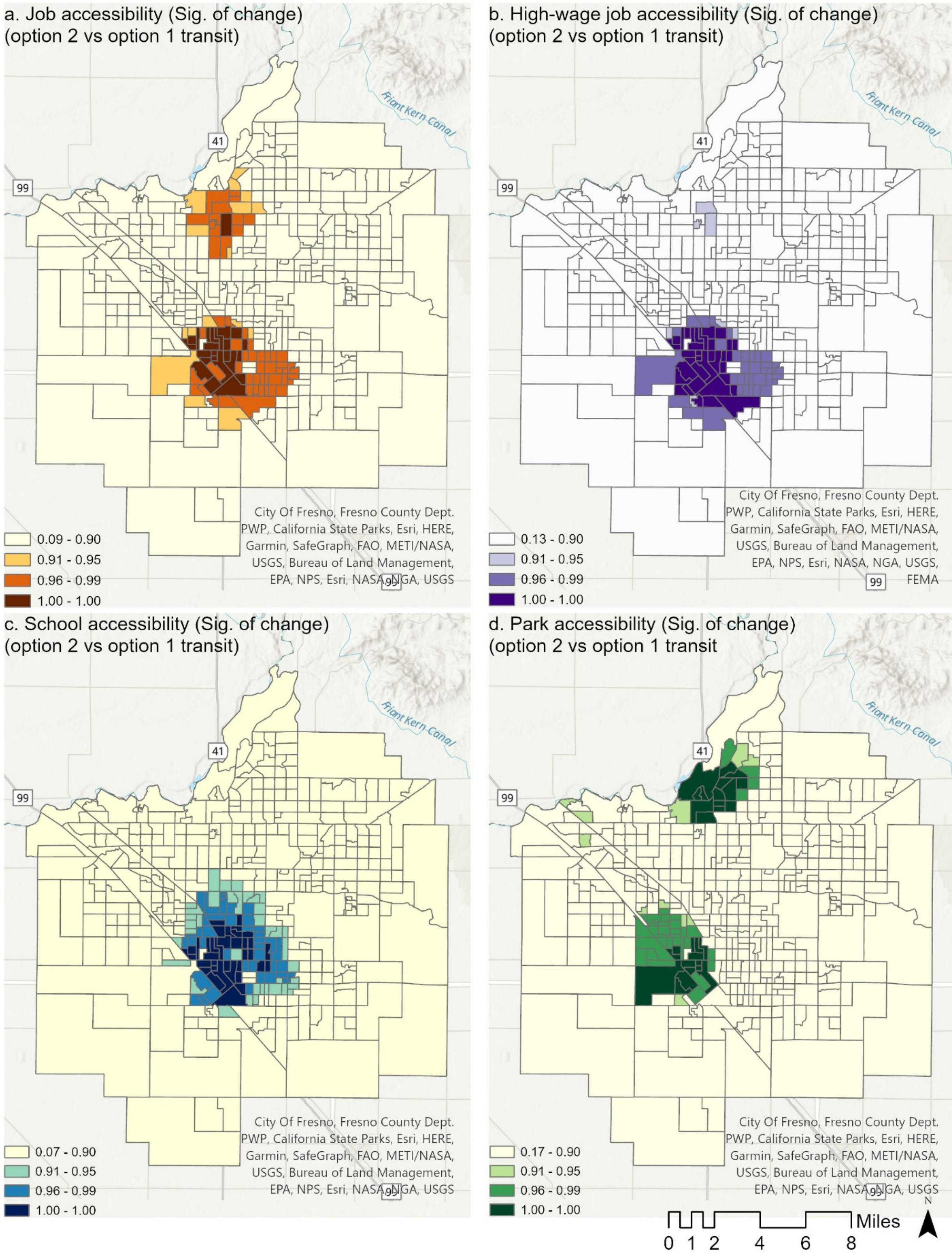
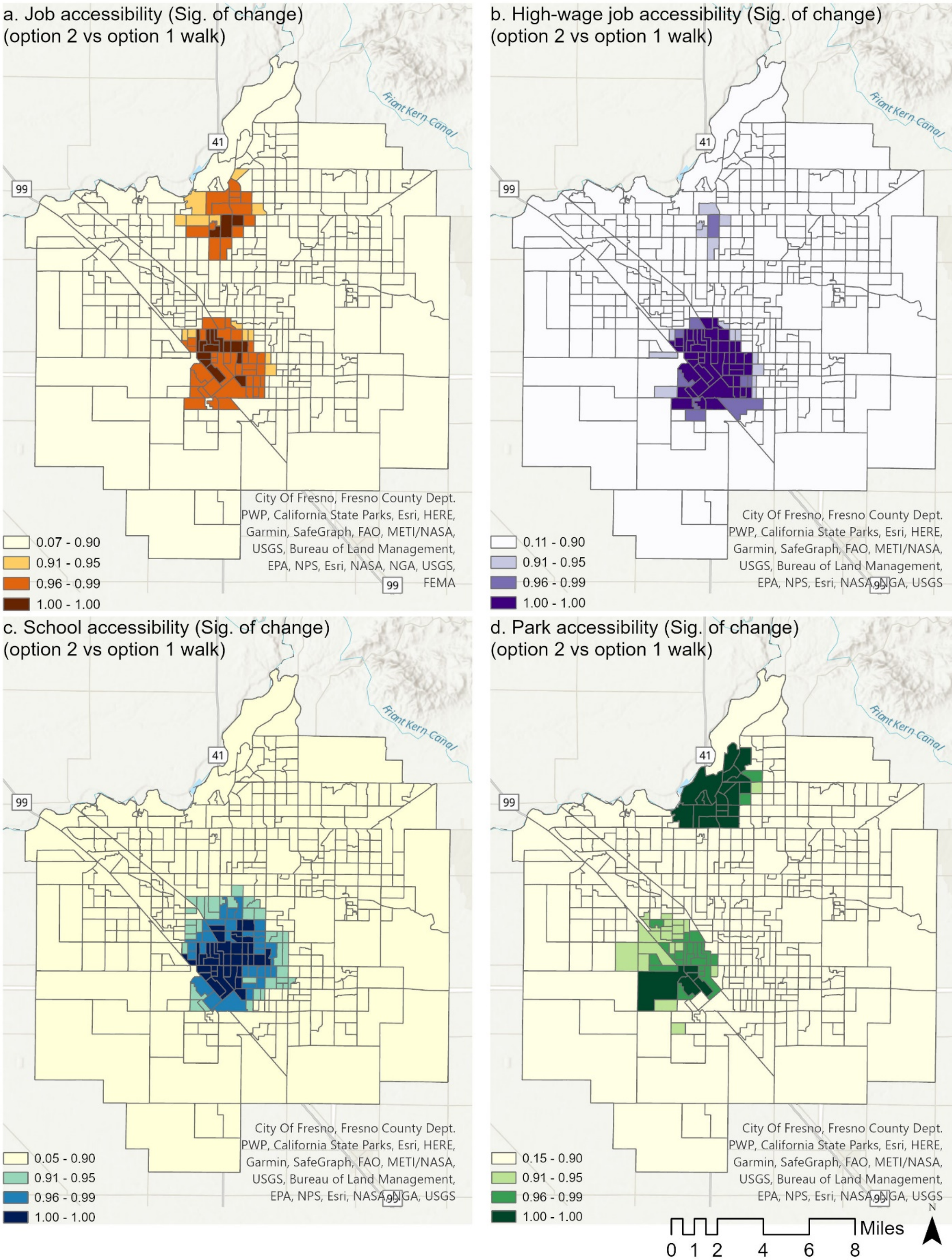


Figure 18. T-test for the New Accessibility by Driving for Fresno



3.4 Contour Mapping

This section compares both the original and new accessibility by driving, transit, and walking between Fresno and Merced. We map the original accessibility to the four opportunities by transit and walking for 45 minutes in Figure 6 and 7. The original accessibility by driving is not shown because there is only a single value across the city. Similar to the approach used in Section 3.3.1, we also make these maps for Merced using the same scales. Thus, accessibility in scales is shown as contours on a map which means that a location in either Fresno or Merced would have the same level of accessibility as another location which has the same color either in Fresno or Merced. We also map the new accessibility to the four opportunities by the three transportation modes for Fresno in Figures 14-16. These maps provide residents with information about where both cities share the same level of accessibility (original and new), and this could be useful when they need to move to a new place.

4. Summary & Conclusions

This study examines how the CHSR would affect the accessibility to work and amenities by three transportation modes (driving, transit, and walking) in the two station cities (Fresno and Merced). Many ideas about future developments in the surrounding areas of the CHSR station in both station cities have been proposed and discussed. This study addresses this problem from the perspective of accessibility. The results provide insight into the problem of future land-use planning and transportation investment to improve accessibility and promote equality for both station cities.

A new analytic framework has been proposed to examine the effect of the CHSR on accessibility and to compare that between two station cities. Such analysis involves considerable calculations and comparisons and, therefore, is difficult. To address this problem, we provide four perspectives for the analytic framework: opportunity costs, conditions for equal accessibility, statistical analysis, and contour mapping. The opportunity costs of using the CHSR have been calculated and mapped for both cities to show the costs of giving up accessible jobs, schools, and parks in the home city in favor of using the CHSR to get to those same opportunities in the other station city. For the conditions for equal accessibility, we have calculated the 45-minute accessibility in the home city as a reference to compare the optional accessibility in the other station city. The difference between the 45-minute accessibility and the optional one has been mapped and shown in % change. The new accessibility (the 45-minute accessibility + the optional accessibility) has also been calculated for both cities. A t-test has been used to identify winners of the CHSR project in terms of accessibility. Finally, the perspective of contour mapping indicates the locations with the same level of accessibility in both station cities. This could be useful for residents in a station city who are considering moving.

Fresno and Merced are the two study regions for this proposed methodological approach. The key findings for the case of Fresno are summarized as follows.

The results of the 25- and 45-minute accessibility by driving indicate that one can easily access most opportunities in the city. It is not surprising that driving is the most efficient and main transportation mode used in Fresno. More importantly, the CHSR does not matter in terms of accessibility in Fresno if driving is the only mode considered in the city.

The results of the 25- and 45-minute accessibility by transit and walking indicate that both transportation modes are inefficient in Fresno. In some maps, one can find that walking is even more efficient for accessibility. This implies that there is room for improvement for active transportation and infrastructure, and the CHSR can be seen as a chance for such a purpose.

The analysis of opportunity costs for transit and walking (the 25-minute accessibility) implies that residents living west of Highway 99 and in the first ring outside of downtown are potential winners of the CHSR because they have lower accessibility as compared to other residents.

The results of the 45-minute accessibility (reference) by transit and walking in Fresno show that better job accessibility clusters in the downtown, River Park, and Clovis; better school accessibility clusters around the city core; and better park accessibility clusters in the outskirts.

The results of the optional accessibility by driving, transit, and walking in Merced through the CHSR simply show that the CHSR would benefit those residents who live closer to the Fresno station.

The difference between the reference and optional accessibility suggests that the winners of the CHSR are those residents living west of Highway 99 (i.e., the southwestern outskirts), which lacks sufficient active transportation investments and opportunities. This location is particularly suitable for those people who are young and focused on work, and therefore, the city can implement the idea of high-density housing here to promote economic equality and environmental sustainability.

The new accessibility (the reference accessibility + the optional accessibility) by transit and walking indicates that there is an increase in accessibility in the first ring outside downtown. This finding corresponds to that from the analysis of opportunity costs. Nevertheless, these increases are small.

The statistical analysis indicates the winners of the CHSR project. The spatial pattern of these winners is similar to the results of the reference (45 minutes) accessibility, implying that the CHSR does not change the pattern of winners in terms of accessibility in Fresno.

Finally, the contour mapping of the reference (the 45 minutes) and new accessibility provide information for identifying the locations with the same level of accessibility in both cities. These maps are useful for comparisons especially when a resident considers moving from one station city to the other.

The CHSR will change the landscape of the Valley, and therefore, there have been many discussions about future developments. However, it is still rare to see a discussion from the perspective of accessibility. The proposed analytic framework can be used not only in Fresno and Merced, but also any other station cities to evaluate how the CHSR affects their accessibility. This study adds to the literature on accessibility and contributes to the practice of active transportation and compact development policies for sustainability.

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