Household Income, Travel Behavior, Location and Accessibility:
Sketches From Two Different Developing Contexts

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ABSTRACT
This paper analyzes the differences in travel behavior and location characteristics across different income groups in two cities in very different parts of the world – Chile and China. Using recent household travel surveys, we compare vehicle ownership rates, mode choices, trip rates and purposes, and travel times and distances according to high, middle, and low income terciles in Chengdu and Santiago. We also compare household location characteristics and present different measures of accessibility. The results suggest commonalities and differences and build a foundation upon which future, more detailed analytical models can be developed and more rigorous and comparable accessibility measures might be derived.

INTRODUCTION
Much remains to be learned about how income affects household transportation and location choices of urban residents in less developed countries. Several major analytical challenges exist, including the rapid pace of change in land development patterns and transportation characteristics (e.g., vehicle ownership) and the lack of data (because they are not collected, quickly obsolete due to rapidly changing conditions, and/or not easily collected for important segments of the population). Attempts to compare among and generalize about the so-called developing world face further challenges of data comparability (e.g., trip definition in surveys) and the enormous range of cultural, regional, economic and other factors that make for as much variation among developing countries as between the developed and developing countries.

Nonetheless, comparative analyses can be useful, to look for regularities in trends, behaviors, and conditions and explore possible reference points on development trajectories. Cameron et al, for example, using aggregate city-wide data propose a generalized model to predict aggregate private motorized distances traveled for cities based on urban area (*1*). Schafer uses data from about 30 travel surveys in more than 10 countries to support the hypotheses of stable average travel budgets (share of time and income) (*2*). Hyodo et al compare trip characteristics revealed through Japanese government-sponsored household origin destination studies for 11 different developing country cities, showing the wide ranges in vehicle ownership, trip generation rates by age and gender, mode shares, trip times, etc. (*3*). Gakenheimer and Zegras examine basic transportation and land use characteristics from a range of cities in Africa, China, South Asia, and Latin America, showing the wide spectrum of motor vehicle ownership levels, presence of motorized two-wheelers, urban densities, non-motorized mode shares, public transportation use, etc. and noting the important apparent role of national motor vehicle industries, common trends towards public transport decline, and near-universal difficulties in land development management (*4*).

In this paper, we make an initial comparison of two cities from two very different parts of the developing world: China and Chile. At first glance, these two countries offer somewhat distant extremes: China, the world's most populous country, with an Eastern-Confucian tradition and existing cities whose foundations date to the pre-Christian era; Chile, a country of 16 million, largely dominated by Western culture and traditions, with most of the existing urban areas dating essentially to the arrival of the Spanish *conquistadores* in the late 1500s. China, despite a huge urban population (in 2000 there were about 37 cities with over 1 million persons), still has, officially, a large share (over 60%) of its citizens living in rural areas. Chile, on the other hand, despite being highly urbanized (nearly 87% of the nation living in urban areas), has just one city with over 1 million persons. Despite these differences, we can see a few common characteristics in the two countries. China, since the early 1980s economic reforms, has exploded onto the global economy, recording average annual growth rates in per capita GDP of almost 11% since 1984 (all figures in this paper, unless otherwise noted, are converted to purchasing power parity (PPP) using implied PPP currency conversion rates (*5*)). Chile, the first Latin American country to embrace the neo-liberal economic model, has also sustained fairly high economic growth rates over the past two decades: with an average annual growth rate in per capita GDP of approximately 6.5% (*5*). As of 2005, Chile ranked 37th among nations on the UN's Human Development Index; China ranked 85th (*6*).

In the face of these contrasts, we make an initial exploration into income group variations in travel behavior, household location, and accessibility in Chengdu, the capital of Sichuan Province, and

Santiago, Chile's capital city. We set out to answer some basic questions, hoping to shed some light on relative similarities and differences in these, on the surface, very different places. Do the poorer income groups have very different travel burdens in the two cities? Do common mode choices and trip purpose shares emerge by income groups? How does relative location influence accessibility? Do the two cities have more in common than first glimpse might suggest and, if so, what might this imply for policies, planning approaches, and planning technologies? We aim to answer these questions in broad-brush strokes, laying the foundation for future, more detailed comparative analyses.

The Contexts of Chengdu, China and Santiago, Chile

China and Chengdu

China finds itself in a state of still initial, yet rapid urbanization and urban expansion, with strong peripheral growth and concurrent intensification of core employment centers (*7*). Despite liberalization of the land market, the state maintains a powerful role, particularly as municipalities now have the abilities and fiscal incentives to transform land to urban uses. Many cities have embarked on large-scale urban renovation projects. Investments in transportation infrastructures have been astounding; Shanghai, for example, made over US$10 billion in transportation infrastructure investments during the five-year period 1991-1996, including in bridges, tunnels, an inner ring road and a subway line (*8*). Gakenheimer and Yang (*9*) identify three intrinsically-linked *growth* forces influencing Chinese cities – national urbanization, increased income, motorization – which filter through four *regulatory* forces – land use reforms, housing commoditization, municipal finance restructuring, and changes in land development standards. According to their analysis, the resulting patterns of metropolitan development across the nation include CBD-focused, polycentric, "garden city"-type suburbs, and completely "new" cities. Generalizing the influence of these development patterns on travel behavior in the "Chinese city" is difficult. Some downtown "gentrification" is taking place, as in the replacement of Beijing's *hutongs* with high-rise apartments. High income households are also tending towards the suburban fringe, in luxury villa-type housing estates, with private motor vehicle access clearly playing an important role. For lower income groups, residential relocation with urban restructuring – and the concomitant disintegration of the communist-economy "work unit" – is also a fact of life, with important travel consequences. For example, an analysis of residential relocation in Beijing and its effects on commuting time, suggests that "reluctant" re-locators (more likely to be lower income groups forced to move due to urban "renewal") suffer increases in commute travel time, on average 11 minutes longer than those who choose to relocate (*10*). Across Chinese cities, there is an apparent decline in public transport share of passenger trips, as the total passengers carried from 1993 to 1997 remained constant or declined, despite an almost doubling in public transit vehicles (*11*). Between 1980 and 2000, average nationwide motor vehicle growth was about 11.3% a year, with the motorcycle fleet increasing at nearly three times that rate (*12*).

Chengdu, the capital of Sichuan province, was built in 316 BC and has a 2,300-year continuous history. The broader municipality of Chengdu has a land area of 12,300 km^2 with 10.13 million people (in 2000), accounting for 11.8% of Sichuan province's population (*13*). The urban population was about 3.36 million. Population densities within the first ring road exceed 360 persons per hectare and within the second ring road are about 130 persons per hectare. The city is typical of the so-called "2nd tier" cities in China and unusual only in that it is in the relatively poor south western part of the country making it likely to attract, along with the other major city in the province (Chongqing), large numbers of rural immigrants. The average annual growth rate in GDP was 14.6% in the 1980s and 21.0% from 1990 to the present (*13*). Steady growth in *formal* population has accompanied economic growth, with an average 1.08% annual growth rate since 1980 (*13*); the PPP-adjusted GDP of Chengdu is approximately US$35 billion, or US$11,000 per person, with continued strong growth expected (*14*).

Chile and Santiago

Chile, already a highly urbanized country, no longer has the same rural-to-urban migration forces as China does today. Like China, however, Chile's urban areas are experiencing the major forces that derive from income growth – e.g., motorization, changing residential preferences – and subsequent urban expansion. Investments in transportation infrastructure have also been massive in recent years; in the Santiago region alone over 200 kilometers of *private sector* concessioned highways are under construction or in advanced planning stages, signifying investments of nearly $2 billion (*15*); another nearly $1.5 billion in public investments has been put into expanding the Metro system (urban heavy rail) over the past few years. Relevant land development drivers, in Santiago and elsewhere in Chile, include continuous demand for low income housing, large-scale real estate mega-projects, and government finance interventions including through some urban revitalization subsidies (see (*16*)).

Santiago, located in the fertile valley of the Mapocho and Maipu rivers, was founded by the Spanish *conquistador*, Pedro de Valdivia, in 1541. Greater Santiago, the contiguous metropolitan area, covers approximately 800-900 square kilometers; with a gross population density of roughly 65 persons per hectare and a net (of roadways, open space) density of 85 persons per hectare. The city is in the region (Chile is divided into 13 administrative regions) known as *Region Metropolitana* (RM), and Greater Santiago accounts for nearly 95% of the RM's population. With roughly 5.5 million persons today, Greater Santiago accounts for one-third the nation's population and is almost 7 times larger than Chile's next largest city. Over the period 1991-2001, population grew by approximately 1.7% per year, average household income by approximately 6.5% per year, and the auto fleet by 6% per year; by 2001 Greater Santiago had nearly 800,000 private motor vehicles (*17*). The PPP-adjusted GDP of the RM in 2004 was approximately $74 billion (*18*), implying a per capita GDP on the order of $11,400.

The Two Cities in Brief

Comparing the two cities, we can see that Chengdu is a smaller city, with much higher city-wide densities, although in the latter case the figures are affected by how the areal boundaries are defined. Based on the regional GDP figures, as converted to PPP, the two cities display roughly comparable per capita GDP levels. This is a surprising result, as we expected Chengdu to have lower levels – the comparisons may be influenced by different national accounting procedures, inaccuracies in the PPP conversion rates, among other factors. Chengdu, much like the rest of China, continues to post strong economic growth figures; Chile's and Santiago's will likely be lower, though still strong and sustained. Given continuous rural-urban migration in China (whether formally allowed by the government or not), Chengdu may quickly reach the size of Santiago; what can we learn and what might these cities' learn from a comparative analysis of transportation, socioeconomic, and land use characteristics?

INDICATORS OF TRAVEL BEHAVIOR

This section reviews basic indicators of travel behavior across the two cities, using information in common from the two available datasets. As we are especially interested in showing the differences in travel outcomes by income categories, we categorized the households from the two cities into income terciles, producing the following (again, in PPP):

- Lowest: Chengdu, below US$8,100; Santiago, below US$10,000.
- Middle: Chengdu, between US$8,101-US$13,500; Santiago, between US$10,001-US$20,000.
- High: Above the Middle tercile cut-off; for Chengdu, the highest recorded income in the survey was over $US $101,000); in Santiago, highest income reported income was US$633,333.

By these figures, we can see that Santiago indeed seems to be a higher income city than Chengdu; the differences get wider with increasing income terciles (e.g., Santiago's broader middle tercile), suggesting higher income inequalities in Santiago. Other data support this conclusion: Chile has a national Gini coefficient of 0.57 (*6*); the estimate for Santiago (calculated from the OD survey), 0.51, indicates slightly less income inequality in the city. In China, the national Gini coefficient is 0.45, while the urban Gini is 0.35 (*19*). For comparison, Denmark, with one of the lowest levels of income inequality among the developed countries has a Gini-coefficient of 0.25; the value for the US 0.41 (*6*).

Data

Conventional travel demand models that account for land use-transport interactions require travel survey and land use data, which are rarely available to the local planning agencies in China. In this context, the China Project at Harvard University, in collaboration with the Research Center for Contemporary China (RCCC) at Beijing University collected travel behavior and location characteristics data for 1001 households in Chengdu. The survey used a spatial sampling technique that overcomes the inability of traditional, household list-based area samples to reach rural migrants to the city (the so-called floating population). A spatial grid was created in the sample space, to create units small enough to be enumerated quickly and cheaply using GPS receivers that can identify small Primary Sampling Units (PSU) with considerable precision. Surveyors then enumerate the households residing within the boundaries of the PSU. Once listed, each household is interviewed. The dataset included a daily activity survey of an adult in each household. The daily activity survey included 2290 trips, which recorded travel time, cost, modes used, and alternative modes available to the trip maker. Location surveys were also conducted for each of the 1001 households and survey respondents recorded travel times to regional locations like the city center, railroad stations, shopping malls, as well as local amenities like parks, markets, playgrounds, banks and post offices. The surveyor then verified the location characteristics. Although a Japanese government (JICA)-sponsored travel survey for Chengdu was carried out in 2000 (*3*), those data have not been made available for public use. The JICA survey did not include the floating population.

Santiago has a good tradition of quality transportation data gathering and modeling, with household origin destination surveys carried out in 1977, 1991, and 2001. The 1991 survey included over 31,000 households (3% of the city's households at the time) interviewed during the work week of the "normal" (i.e., not summer) season. The 2001 survey demonstrates advances in the state-of-the-art. While a smaller sample was used, all days of the week were included (including weekends) as was the summer season. 12,000 households were surveyed during the "normal season" and 3,000 during the summer time (in total, 1% of Greater Santiago's households), including 59,763 persons and 153,413 trips. The 2001 survey included all trips in the public space (irrespective of distance), by all household members (regardless of age), 13 trip purposes, and 28 different modes or mode combination. Trip origins and destinations were geo-coded at nearest street corner (sometimes census block). Socio-demographic data include individual educational level, job status, household income, number of motor vehicles, etc. Household information is geo-coded at the census block centroid (nearly 50,000 blocks) (for more detail, see (*20*)).

In recent years Chilean authorities and academics have invested considerable effort to develop a land use model that can be integrated with local travel modeling capabilities (see *21*). To "feed" the model, authorities initiated an effort to compile land use data from national tax records and business and land use permits (as reported to Municipal governments); the data for 2001 include information (e.g., type of use, floor space constructed, parcel size) for roughly 1.3 million residential units and 400,000 non-residential land uses (17 different land uses, total), geo-coded at the street address or sometimes the census block. Data were not available for rapidly suburbanizing parts of the city, which were however, included in the origin-destination survey.

To make the comparisons between the two cities consistent, the Santiago trip characteristics presented below include trips made during a normal work week by persons over 15 years old (reducing the sample size to 9,038 households; 26,484 persons; 76,465 trips). For the Santiago data, the averages presented below use the factors prepared for government authorities to correct for sample bias, adjusting the survey to reflect socioeconomic and demographic information from the 2002 Census. Such correction factors were not available for the Chengdu survey because the Census housing lists exclude migrants. In 2000, the population in Chengdu over 15 included 8.6% students, 68.0% employed and 23.4% others (*16*) in 2001 comparable figures for Santiago are 17% students, 50% employed, and 34% others. The Harvard-RCCC sample indicated that only about 2% of the trips were by those over the age of 65; in Santiago 5% of all trips were by 65+.

Vehicle Ownership and Mode Choice

Unsurprisingly, higher income households have higher car ownership rates in both cities (Table 1). Generally, Santiago displays much higher motorization rates, as reflected in the share of households in each income category that has at least one automobile. Yet, the data reveal some interesting insights. One, when motorized two wheelers are added to the household motorization rate, for low and middle income households in Chengdu the level of motor vehicle availability in the two cities becomes more comparable (0.16, low income and 0.25 for middle income, compared to 0.18 and 0.40 in Santiago) – consistent with other analyses showing that motorized two-wheelers in Asia "level" the motorization rates relative to the non-two wheeler developing country "cultures" (*4*). Even with this adjustment, the highest income tercile in Chengdu has fairly low vehicle ownership rates – still below that for Santiago's middle tercile. This difference may result from higher household incomes in Santiago's middle and high income terciles. We see another interesting result when comparing motorization rates for households with at least one driver's license: households across the income categories display almost identical motorization rates.

A surprising result is that all income categories in Santiago had higher bicycle ownership rates. In fact, in Santiago household bicycle ownership increases with income while in Chengdu it declines – in Santiago bicycles appear to be a "superior good" while in Chengdu they are an "inferior good." This likely reflects more recreational bicycle ownership in Santiago, which is confirmed by the mode share data discussed below. Motorcycles and motorized two- and three-wheelers show very low household ownership rates in Santiago compared to Chengdu, even though in Chengdu motorcycle use is banned within the inner ring (electric bicycles and tricycles are exempt from this ban).

TABLE 1 Household rates of vehicle ownership by income

		Income Categories		
		Low	*Middle*	*High*
Santiago Chile	Cars	0.18	0.40	1.08
	Motorcycles	0.01	0.01	0.02
	Bicycles	0.66	0.90	1.12
Chengdu China	Cars	0.03	0.08	0.19
	Motorcycles	0.13	0.15	0.15
	Bicycles	0.50	0.39	0.39
For households with licensed drivers				
Santiago	Cars	0.35	0.65	1.20
Chengdu	Cars	0.36	0.67	1.07

Note: For Santiago, cars include all four-wheel motor vehicles.

The much higher household motorization rates in Santiago are reflected in higher auto mode shares (Table 2) for all income groups. Indeed, Chengdu's high income trip makers have an auto mode share nearly the same as low income trip makers in Santiago. Santiago has much higher across-the-income-spectrum public transport mode share – including Metro (Santiago's 50 km (in 2001) urban heavy rail system), 30% to 40% higher. The Metro appears to be a superior good in Santiago, as its mode share increases with income (for these broad income categories). Overall public transport mode share in Santiago is two to three times higher than in Chengdu, whose citizens make up for the relative mobility gap by, not surprisingly, high bicycle use. Though *Santiaguino* households have high bicycle ownership rates, they do not apparently use those bicycles that often, while in Chengdu bicycles account for one-third of all trips, irrespective of income category. People in Chengdu also tend to walk more than those in Santiago, particularly as incomes grow. Overall, Chengdu is a more non-motorized dominated city; in Santiago, relative to Chengdu, lower income households take the bus instead of the bike, medium income households take the car at the expense of walking; and high income households further intensify the shift to car at the expense of walking and the bus. Across income categories, Santiago displays higher differences in mode share than Chengdu; possibly reflecting the higher income disparities in Santiago.

TABLE 2 Mode Shares for Trips by Income

		Income categories		
		Low	*Middle*	*High*
Santiago	Car	9.5%	17.4%	42.8%
	Motorcycle	0.3%	0.2%	0.3%
	Taxi	3.7%	3.8%	3.5%
	Bus	32.0%	34.8%	23.1%
	Metro	2.1%	4.6%	7.1%
	Walk	47.9%	35.0%	20.8%
	Bike	3.2%	2.5%	1.0%
Chengdu	Car	4.0%	3.5%	9.6%
	Motorcycle	0.0%	0.9%	0.0%
	Taxi	1.7%	0.7%	2.0%
	Bus	12.7%	10.4%	13.1%
	Walk	49.4%	51.7%	43.1%
	Bike	32.0%	32.3%	31.6%

Notes: Work day trips for persons 15+. For Santiago, taxi includes shared fixed-route taxis (*colectivos*); Metro includes all combinations. Figures may not add to 100% as minor modes were not included.

Trip Purposes and Characteristics

Relative trip purpose shares between the two cities may be a simple function of income levels and subsequent work requirements and leisure time availability. *Santiaguinos* make nearly three trips per person per day, increasing slightly with income, consistent with evidence from other places (*2*). Across income categories, residents in Santiago have higher trip rates than in Chengdu, on average 0.4 to 0.6 higher, a result again consistent with Santiago's higher household incomes. A larger share of Chengdu residents' trips are for work. *Santiaguinos* make a higher share of shopping, school and recreation trips, with the latter two fairly constant across income groups and the former declining with increased income. In both cities shopping trip share declines with increasing income – in Santiago this might be partly attributable to domestic help, who likely take care of an important portion of higher income daily shopping requirements; which might also be reflected in the lower income higher shopping share. Alternatively or additionally, the lower income groups might be forced to make more shopping trips as they are less likely to be able to "trip-economize," such as making one large-load car-based trip to, say, a big-box retailer. In Santiago, the "return to home" trip share declines with income. This could represent higher trip-chaining propensity with increased income, as automobile travel makes trip chaining easier and relatively more economical. In both cities, the lower work trip shares for the lowest income groups – particularly notable for Santiago – likely reflect unemployment or temporary employment.

In terms of trip times, Santiago shows higher average trip times than Chengdu. Trip distances in the two cities, beyond for the lower income groups, however, are fairly comparable. This makes it difficult to explain Santiago's higher average trip times: for example, for middle income groups it is nearly three times higher than in Chengdu (43 versus 18 minutes), despite comparable distances (5.8 versus 5.5 kilometers). The work trip accounts for a good share of the time differences, possibly a legacy of the work-unit economic structure in Chengdu and the lack of large-scale residential decentralization, as of yet. Also, traffic in Chengdu likely moves at relatively higher speeds due to lower vehicle ownership. Some of the differences may be due to survey technique and errors. For example, the Chengdu survey used reported distances, while the Santiago distances come from the reported origins and destinations.

TABLE 3 Trip Purpose Shares by Income

		Income Categories		
		Low	*Middle*	*High*
Santiago	Trip Rate (trips/person)	2.83	2.86	2.96
	Return Home	45.0%	43.2%	39.1%
	Work	10.6%	16.4%	18.2%
	School	4.4%	4.6%	5.2%
	Shopping	13.1%	10.9%	8.7%
	Recreation	2.5%	2.1%	2.7%
Chengdu	Trip Rate (trips/person)	2.35	2.46	2.39
	Return Home	47.5%	48.3%	47.9%
	Work	19.3%	21.5%	24.3%
	School	3.6%	3.4%	2.5%
	Shopping	6.7%	3.4%	3.8%
	Recreation	0.5%	0.4%	0.4%

Note: Work day trips for persons 15+.

TABLE 4 Trip Characteristics by Income

		Income Categories		
		Low	*Middle*	*High*
Santiago	Avg. Trip time (minutes)	28	33	33
	Trip Time (work)	43	43	36
	Trip Time (non work)	25	28	28
	Avg. Trip Distance (kms)	4.7	5.8	6.2
	Trip Distance (work)	9.3	9.6	8.5
	Trip Distance (non work)	4.1	5.1	5.6
	Trip cost PPP US$	$0.41	$0.47	$0.49
Chengdu	Avg. Trip time (minutes)	22	18	21.5
	Trip Time (work)	19	16	18
	Trip Time (non work)	21	21	26
	Avg. Trip Distance (kms)	2	5.5	5
	Trip cost PPP US$	$0.39	$1.16	$2.64

Notes: Work day trips for persons 15+. In Santiago the distances are based on straight line distances between Origin-Destination points, adjusted for network distances based on an adjustment factor provided by authorities. Chengdu trip distances are reported by survey respondents. Data on trip distance by disaggregate purposes not available for Chengdu. For Chengdu, the costs were based on those reported in the survey; for Santiago, public transport costs were based on those reported in the survey, private transport costs were based on distance traveled and estimated vehicle fuel efficiency and cost in 2001.

In Chengdu, work trip times are fairly constant across income groups, while in Santiago the highest income groups have the lowest work trip times. In this case, we see higher income effects in both relevant dimensions in Santiago: higher income persons, on average, live closer to work; at the same time they benefit from their access to higher speed travel modes (the auto). A reverse effect is detected for discretionary trips, lower incomes bring lower travel times, but with much shorter distances. Not surprisingly, the poor are constrained in their non-work destination choices; income increases “purchase” more destination opportunities with only slight time increases. A similar phenomenon plays out in Chengdu, where the wealthiest groups have longer non-work trip times. In the case of Chengdu the highest income group reports an average distance of 2.9 km from the shopping mall they often visit compared to an average of 2.3 km for middle income household and 2.6 km for the lowest income group. The Chengdu average trip cost figures further confirm this phenomenon – the higher cost buys speed and distance, and the wealthier are willing and able to pay. In Santiago, the average trip cost across the three income categories shows little variation – in this case, since the automobile travel cost includes only the estimated fuel cost per trip, the costs for middle and higher income households is underestimated. Interestingly, costs for the lowest income categories in the two cities are very comparable.

HOUSEHOLD LOCATION CHARACTERISTICS AND EXAMPLE ACCESSIBILITY MEASURES

Location Patterns

Table 5 suggests a trend of increasing distance from the CBD with income for Chengdu, which is reversed in Santiago. A basic indicator, it still provides for interesting stylized portraits of metropolitan socioeconomic structure. Santiago, similar to many other Latin American cities, has historically displayed strong socioeconomic spatial segregation (*16*), manifested in the "cone of wealth" – a concentration of higher income areas extending East/Northeast from the CBD into the Andean foothills (Figure 1). Low income communities historically settled in waves on the urban outskirts, a concentration intensified during the Pinochet regime when informal settlements were forcefully dispersed to new social housing on the fringe (not unlike what is occurring in some Chinese cities today). As a result, higher incomes tend to, on average, locate closer to the CBD (in the past 15 years a new CBD has emerged in Santiago, roughly 4 kilometers east of the traditional CBD, eroding the idea of a single CBD in Santiago), while lower income households concentrate especially in the south/southwest (Figure 1 shows percentages of households in each zone, not total populations). This urban pattern is, nonetheless changing, especially with current intense upper income suburbanization in the city's north.

TABLE 5 Basic Location Characteristics by Income

		Income Categories		
		Low	*Middle*	*High*
Santiago	Distance from CBD	11.7	11	9.4
Chengdu	Distance from CBD	7.9	9.1	10
	Time from CBD	18.7	18	21.5
	Time to nearest shopping mall	11.9	13.9	10.6
	Time to nearest park	13	16.8	13.2
	Time to nearest food market	6.7	6.6	6.7

Notes: For Santiago, distance to CBD measured as straight-line distance from household's census block centroid to the *Plaza de Armas*, the heart of the historical central business district.

The Chengdu maps (Figure 2) also confirm the stylized portrait from the distance to CBD measure and the inverse locational patterns, with concentrations of higher income on the edge and lower income towards the city center. Population densities vary considerably, with higher density in the western locations especially in the southwest (Figure 3). Growth in the south-western and western parts of the city reflects a regional trend since the 1990s with growth towards the airport in the southwest (*22*). Municipal government policy during the 1990s was to drive development to the southeast but the Provincial government supported a high-tech zone to the northwest (*22*). Development towards the west has tended to dominate, especially with higher densities in the southwest. Low-income households appear to be located in both the high density south west as well as the low density north east (with a high concentration of migrants near the northern railway station). Upper income households show concentrations along the outer ring roads and the radial highway corridors on the southeast, north, south and northwest.

FIGURE 1 Spatial Distribution of Percentage of Households by Income Category in Each Zone: Santiago
(Expanded from the 2001 Origin-Destination Survey to the Traffic Analysis Zones)

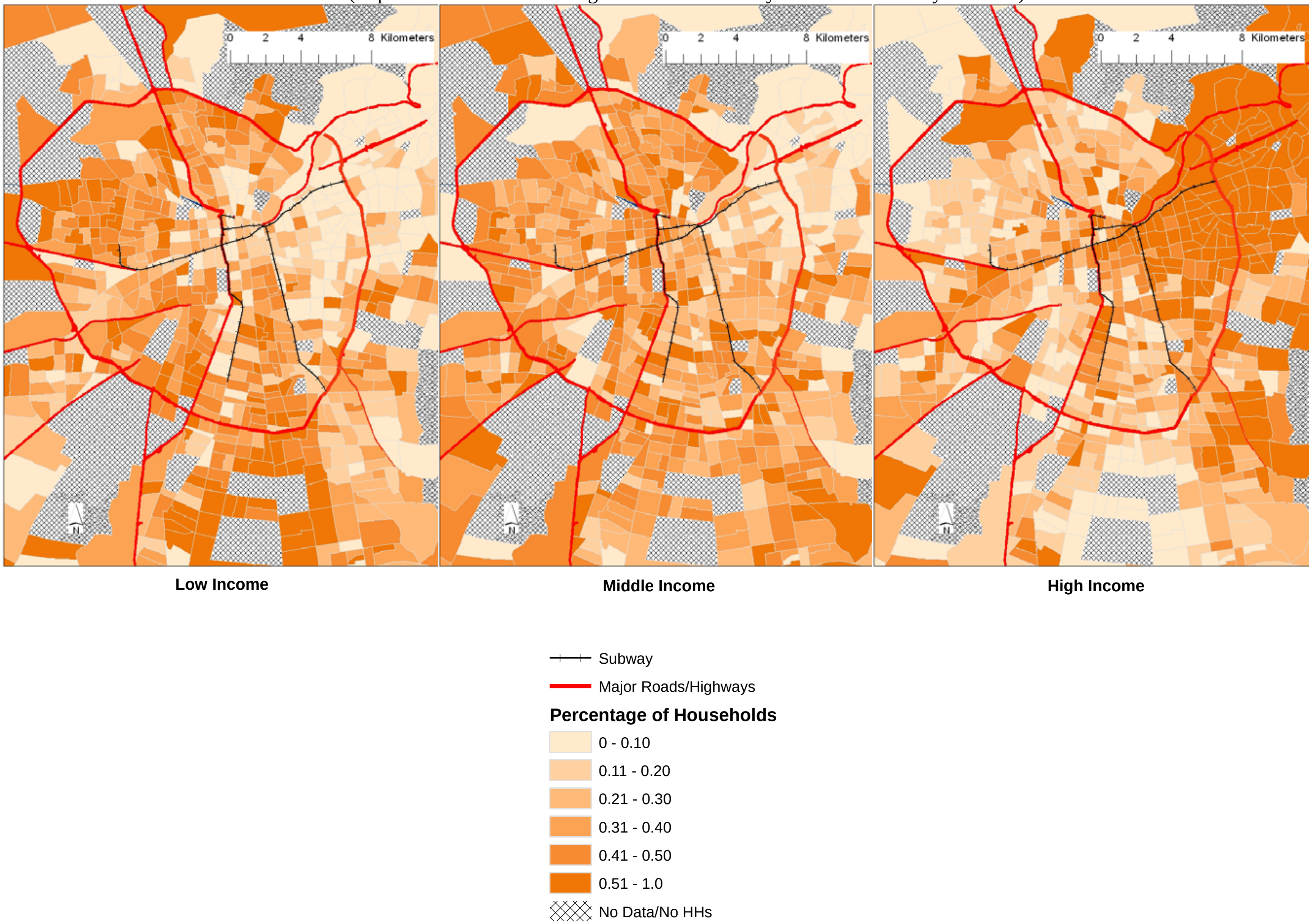


FIGURE 2 Spatial Distribution of Percentage of Households in Each Income Category: Chengdu
(Thiessen polygons were created around the sampling locations)

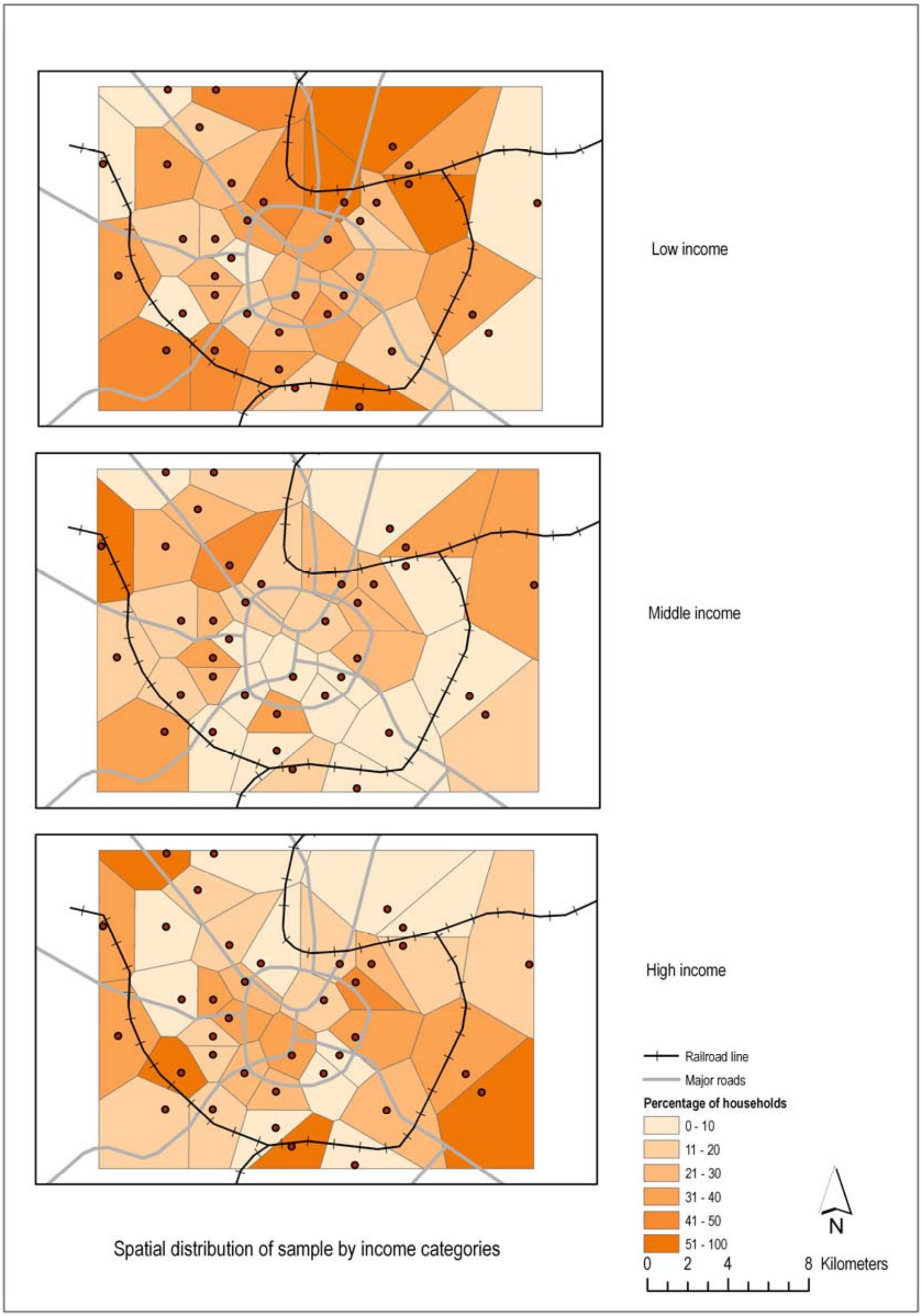
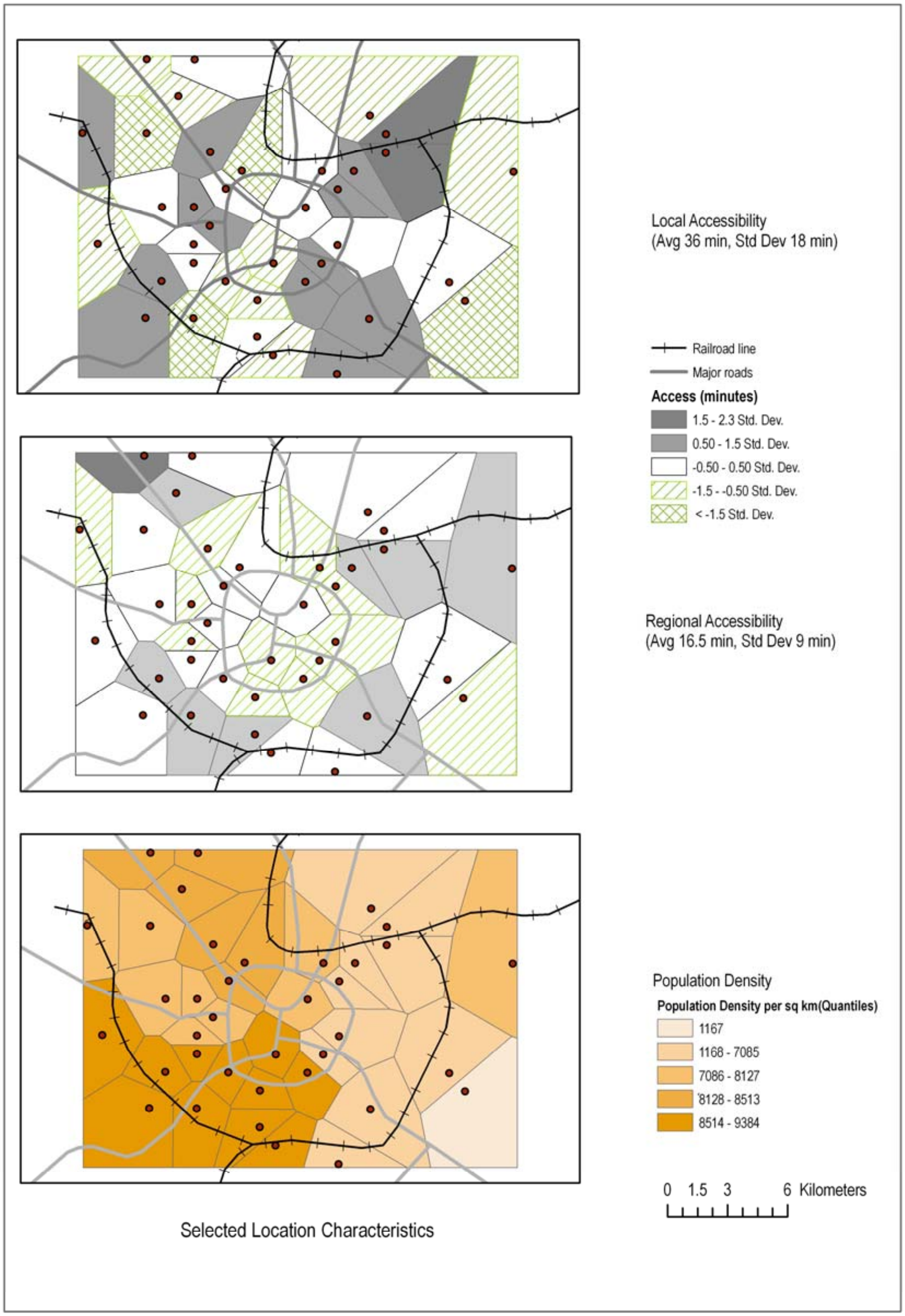


FIGURE 3 Population Densities & Infrastructure-Based Accessibility Examples: Chengdu
(Thiessen polygons were created around the sampling locations)



Accessibility Measures

Accessibility can be defined as the “extent to which the land-use and transportation systems enable (groups of) individuals to reach activities or destinations” (*23*, p. 128). As such, accessibility depends on transportation system performance, land use patterns, individual characteristics, the overall quality of “opportunities” available, and the communications system. Accessibility represents the *raison d’etre* of the land use-transportation system – the benefit/welfare that is ultimately derived for users (see, e.g., *24*). Despite this theoretically appealing concept and some fifty years of exploration, measures of accessibility that capture its full meaning remain difficult to operationalize, much less translate into useful indicators. Various types of accessibility measures exist, from simple infrastructure-based measures – such as travel speeds – to the gravity model, to more complex measures, such as Hagerstrand’s space-time prism. The more complex measures tend to better adhere to the fundamental meaning of accessibility, yet quickly become data- and computationally-intensive. Here we use a fairly straightforward infrastructure-based accessibility measures to describe outcomes of the land use transportation system in Chengdu and then present more complex, utility-based accessibility measures to demonstrate characteristics in Santiago.

Example of Accessibility Measures in Chengdu

We present non-work accessibility measures for Chengdu in terms of travel time – reported in the Harvard-RCCC travel survey – to food markets and parks. Based on the time to nearest food market, no major differences appear across the income categories; for time to the nearest park, middle income households have the highest travel time, 3 minutes higher than for low and high income (Table 5). Figures 2 and 3 show that locations with relatively high income households appear to also have better access to the city center. Locations with poor local accessibility (measured by average access time to the nearest park, shopping mall, food market, and post office) tend to have higher low income concentrations. Locations with high middle income concentrations are relatively accessible with respect to the CBD but have poorer local accessibility. Land uses in areas with a more poor households appear to be more mixed with industrial uses as compared to locations with more middle and high income households; this may explain lower income groups’ low average trip distances (Table 4).

Example of Accessibility Measures in Santiago

For Santiago, we present an example of a more complex accessibility measure, derived from a nested logit model of destination and mode choices for recreation and social trips (*24* presents model specification and estimation). Accessibility measures of this form are known as “utility-based” accessibility measures, due to their direct derivation from the random utility, discrete choice models. Ben-Akiva and Lerman (*25*) make the explicit link between discrete choice models and the accessibility concept, defining accessibility as “the utility of the choice situation to the individual” (p. 656). The denominator of the model represents the expected maximum utility from the total choice set for an individual – interpreted as accessibility. Sometimes referred to as “logsum” values, due to the underlying mathematical form, utility-based accessibility measures offer several benefits, including their ability to reflect individual preferences and their direct relation to traditional consumer surplus measures (e.g., *26*).

Figure 4 shows absolute recreation and social (visit trips) accessibility for an average adult female in the three different income categories. The results suggest a strong mono-centric orientation of accessibility. Some degree of spatial variation in the most accessible zones for different income groups can be detected, primarily reflecting travel cost sensitivity of the different income groups. The top three maps in Figure 4 show the relative accessibility distribution, by quintiles, within each income category, for recreation trips. Overall, we see increased income translates into higher accessibility. The bottom three maps show the distribution of middle and high income social accessibility within the same quintiles as the low income. These figures show that a middle income woman would enjoy the same or higher levels of accessibility for social trips in roughly 70% of the city as a lower income woman would enjoy in just 20% of the city (similar results were found for recreation trips; see *24*). The results show clear inequities in accessibility. The inequities can also be seen by comparing the areas of highest accessibility for low income groups with the primary areas of concentration of low income households (Figure 1). In general, few low income households live in areas with high recreational or social accessibility.

CONCLUSIONS

Using recently collected travel survey data, we have presented portraits of mobility and accessibility – across three basic income groups – for two very different urban contexts: Chendgu, China and Santiago, Chile. Both cities come from countries that have sustained strong income growth over the past two decades, but that also represent very different cultures, histories, and economic systems. Santiago, a wealthier city, also has higher income disparities, while Chengdu faces greater population pressures with continued rural-urban migration. Across all income categories, Santiago has higher household motorization levels; in Chengdu, the two- and three-wheeled motor vehicles modestly compensate this difference. For households with drivers' licenses, however, the motorization rates are quite comparable. Chengdu confirms the still non-motorized dominance of the Chinese city; compared to Chengdu, low income people in Santiago take the bus instead of the bike, medium income households take the car at the expense of walking; and high income households shift to the car at the expense of walking and the bus. The data also suggest that, consistent with their higher incomes, *Santiaguinos* make more trips per day, most of the additional trips coming from shopping and recreational travel. In terms of trip distances and times, both cities show the lower incomes being constrained in terms of non-work destination choices.

We also presented two different types of accessibility measures in each of the two cities. Accessibility represents the fundamental benefit of the land use-transportation interaction space. The rigorous derivation of accessibility indicators requires reliable data on land uses and travel behavior, ideally disaggregated to the lowest possible geographical unit and to the individual to better show, for example, variations in spatial distribution of accessibility by income and gender. For example accessibility for the licensed driver in a household with a car will differ from a non-driver in the same household whether it is located in Chengdu or Santiago. The accessibility measures presented here show how income differences affect household locations in the two cities and, thereby, the local and regional accessibility of the household.

Building off this preliminary analysis, this work could be extended to develop, for example, models of mode choice and trip frequency that include independent variables measuring location characteristics and socio-economic indicators like income and gender. Such models can provide more refined views of the similarities and differences in the two cities and may allow for deriving comparable accessibility measures, using, say, the utility-based accessibility measures developed for Santiago. The purpose would extend beyond cross-city comparisons; such measures could also lend directly to improved measures of land use-transport system performance and directly aid decision-making. For example, the spatial distribution of accessibility of a low income migrant worker in Chengdu could help in deciding the best locations for bicycle or pedestrian paths; understanding the impact of local and regional accessibility on transportation choices might help identifying appropriate Bus Rapid Transit (currently on the Vice Mayor's agenda) planning and planning for future high density corridors. The ultimate goal is to use improved data and analytical techniques for better integrating land use-transportation planning.

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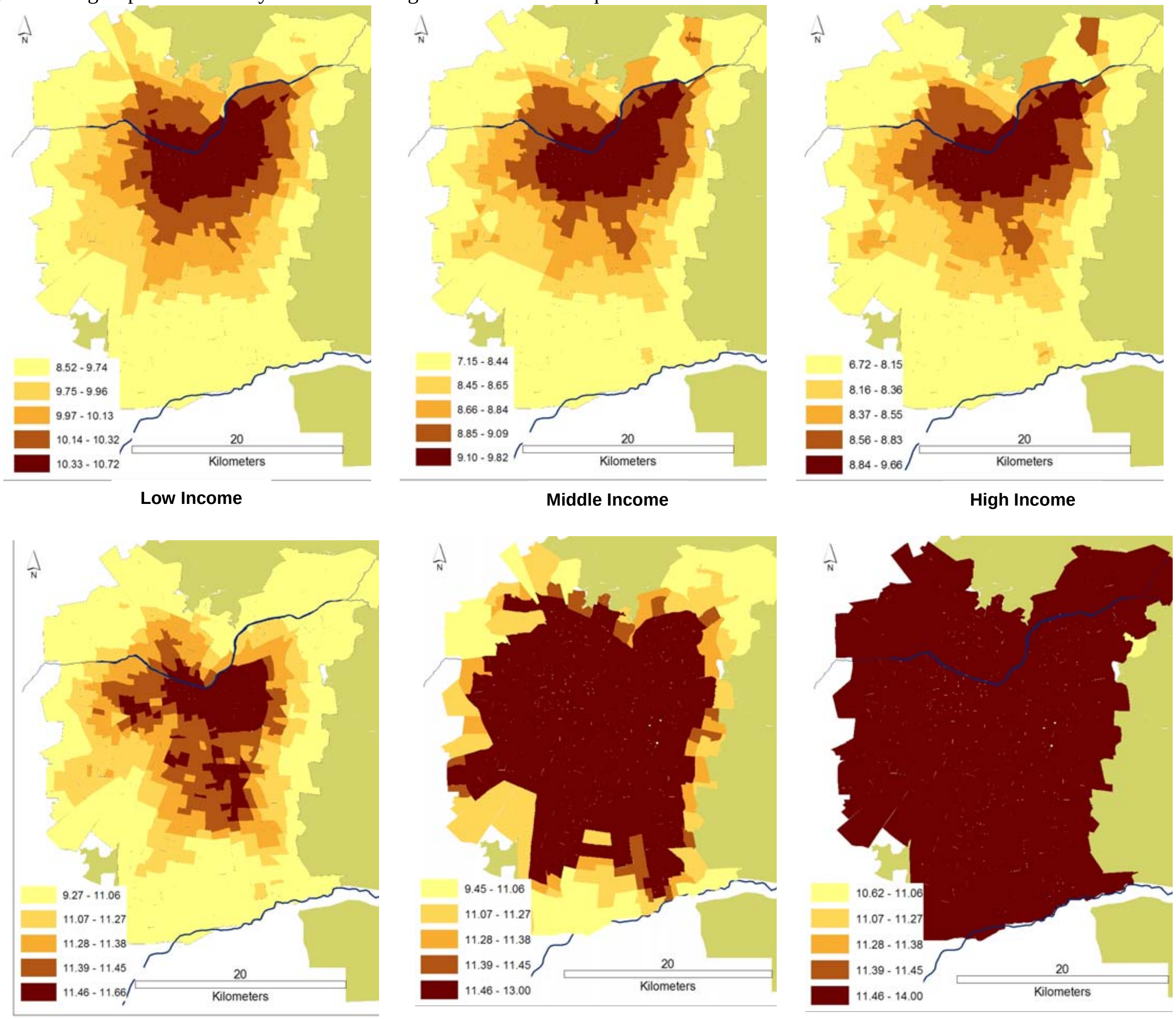
FIGURE 4 Recreational and Social Accessibility (Logsum) for Female by Income Category

Notes: In the top three maps, the shades represent quintiles of recreation trip accessibility *within* each income category. The lower three maps show the middle and high income groups' accessibility levels according to the low income quintiles.



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