Public transport and livelihoods in a fast-growing lower-middle income city: Praia, Cape Verde

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Abstract

This paper evaluates public transport accessibility to formal and informal employment opportunities in a city in a middle-income country: Praia, the capital of Cape Verde. Due to geographic constraints and rapid growth of population, income, road network, and car ownership, employment is dispersed throughout the city. Public transport is limited in terms of geographic coverage and connectivity. Accessibility is evaluated in terms of the number of bus trips required to access work places and the walking times to bus stops. The results show that deprived areas are at a disadvantage in the access to formal employment opportunities when comparing with more affluent areas. Some areas also have limited accessibility to spaces for informal employment, when considering public transport options and competition for these spaces.

1. Introduction

Equity is a growing concern of transport and urban planners around the world, due to evidence on the links between job accessibility and the employment prospects of groups such as low-qualified workers, ethnic minorities and young adults. Cities in middle income countries face particular challenges, due to the increasing geographic mismatch between residences and jobs and to the limitations of the public transport system.

The paper evaluates the role of public transport in providing access to job opportunities and sources of livelihood in Praia, the capital of Cape Verde. The emphasis is on the equity of the system, evaluating the extent to which the bus network meets the accessibility needs of different groups in society. The accessibility levels of economically-deprived populations to formal jobs are compared with those of more affluent populations. The accessibility of economically-deprived populations to spaces for informal trading is then mapped, taking into account the competition for those spaces. The analysis identifies the groups and areas at greatest disadvantage and the areas offering the highest potential for expansion of the bus network, considering the matches between people and jobs.

Accessibility is evaluated by two variables chosen after consideration of the characteristics of transport and land use in cities in lower-middle income countries, and the results of a survey to the population in the case study area. In a small city with a large proportion of poor households, public transport accessibility is less about travel time than about the number of bus trips required to reach workplaces. Since the bus network covers only part of the city, accessibility also depends on walking to bus stops. The analysis then considers the number of bus trips required to access work places and alternative assumptions on the maximum walking times to access bus stops. The estimation of walking time considers the use of informal space for walking and the effect of slopes on walking speeds.

The paper proceeds as follows. Section 2 reviews the literature on equity issues in the transport systems of developing countries, with emphasis on the trends affecting cities in lower middle income countries. Sections 3 and 4 introduce the study area and report the results of a survey to people's perceptions and behaviour. Section 5 analyses the distribution of levels of public transport accessibility to formal employment and Section 6 focuses on the accessibility of female slum dwellers to areas for informal trading. Section 7 maps the areas where expansion of the bus network would bring higher gains in the number of matches between people and jobs. Section 8 synthesizes the findings of the study.

2. Transport and equity in developing countries

Equity aspects have slowly been making way into transport policy, as consensus emerge about concepts such as social exclusion [Hine 2003, Lucas 2004, Lucas and Stanley 2009] and environmental justice [Feitelson 2002, Lucas 2004, Forkenbrock and Sheeley 2004]. However, the application of these concepts to the case of developing countries is not straightforward. Lucas (2011) argues that the identification of social exclusion as a policy concern needs to take into account that transport poverty in developing countries is a problem of the majority, rather than of a minority of the population. Becker (2012) also reports nuances in the understandings of equity issues by transport policy-makers in an African city.

Vasconcellos (2001) and Dimitriou and Gakenheimer (2011) provide overviews of the different channels through which those systems contribute to the reproduction of economic and social inequalities. The relevance of economic factors for urban accessibility is identified as a major issue in these and other studies. Accessibility is closely related with livelihoods of disadvantaged groups, but the use of the transport system by these groups is also limited by cost.

Transport disadvantages in developing countries are increasingly related with geographic factors. The mismatch between population and jobs identified since the 1950s in North American cities is often pointed as a cause for the poor employment outcomes of some groups [Gobillon and Selod 2014]. There is evidence that this hypothesis also applies in cities in developing countries [Wang *et al.* 2011, Lau 2011], as their patterns of land use become similar to those in North America. Urban growth in these countries also tends to be accompanied by employment decentralization [Cervero 2013]. The fragmentation of urban space can also be observed in cities that grew from settlements established during the colonial period in locations chosen according to the benefits they brought to the colonial economy. As cities expand, they start to cover nearby areas where mobility is limited by relief and environmental risk. The areas with the most severe limitations are not attractive either to affluent classes or to employers and tend to be occupied informally by poorer households.

The growth in population and income also leads to a greater diversity in neighbourhood types [Kombe 2014], including suburban developments, satellite towns and redeveloped or gentrified neighbourhoods. These changes in land use tend to increase the inequality of access to infrastructure and amenities [Leichenko and Solecki 2008]. Residential segregation is also facilitated by the separation of neighbourhoods by transport and other infrastructure and by the increased popularity of gated communities [Akgün and Baycan 2012, Morange *et al.*

2012]. Ortiz (2014) suggests that these processes originate a divide between "cities without citizens" (low-density residential areas or areas with employment concentrations with full access to urban infrastructure) and "citizens without cities" (informal areas without employment and infrastructure).

The mismatch between residence and jobs depends not only on geographic distances but also on the suitability of transport to cover those distances. The growth in average income increases car ownership rates and road traffic demand, which is accommodated in new road infrastructure where priority is given to the circulation of private vehicles over public transport and non-motorised modes [De Langen 2005], increasing the disadvantage of individuals without access to cars. Lower middle income countries face particular challenges, as informal public transport systems are less available than in poorer countries but formal bus networks have limited geographic coverage, comparing with richer countries.

There is evidence that insufficiencies of the public transport supply in developing countries limit access to employment and services for woman [Porter 2008] and poorer households [Olvera et al. 2013] and have an impact on the quality of life of older people [Olawole and Aloba 2014]. However, the provision of public transport requires the consideration of several types of costs and benefits. Dávila (2013) provides a thorough analysis of the political, technical and financial challenges of providing public transport to hilly areas in two Latin American cities, balanced against the benefits in access to jobs and facilities and the social and psychological aspects of connecting neighbourhoods that were previously perceived as marginal to the urban space.

The need to consider equity aspects is unavoidable when evaluating public transport accessibility. During the last decade, evidence collected in different countries has pointed to the gap between the opportunities accessed with private and public transport from each neighbourhood in the city [Kwok and Yeh 2004, Kawabata 2009, Grengs 2010, Benenson *et al.* 2010]. The distribution of levels of public transport accessibility across the city may also be unequal, an issue of special concern when the neighbourhoods at disadvantage have low income and low rates of car ownership. Delmelle and Casas (2012) studies the case of the bus system in a Colombian city, finding that access to the system itself favours the middle classes, but access to the final destinations depends on their spatial distribution of these destinations. In a separate study for the same city Jaramillo *et al.* (2012) analysed public transport provision in terms of a wider set of socio-economic variables defining need for transport, finding more complex distributive patterns.

The choice of the indicators used for studying accessibility gaps between different groups is an important issue, as each indicator is linked to an implicit concept of equity [Páez *et al.* 2012]. The extent to which the indicators used measure the actual well-being of the populations also depends on the context. Studies in developing countries have shown that the high cost of fares and the limitations in transport supply (in terms of availability of services and distance to bus stops and terminals) are the main reason for the lack of accessibility of low-income populations [ITRANS 2004].

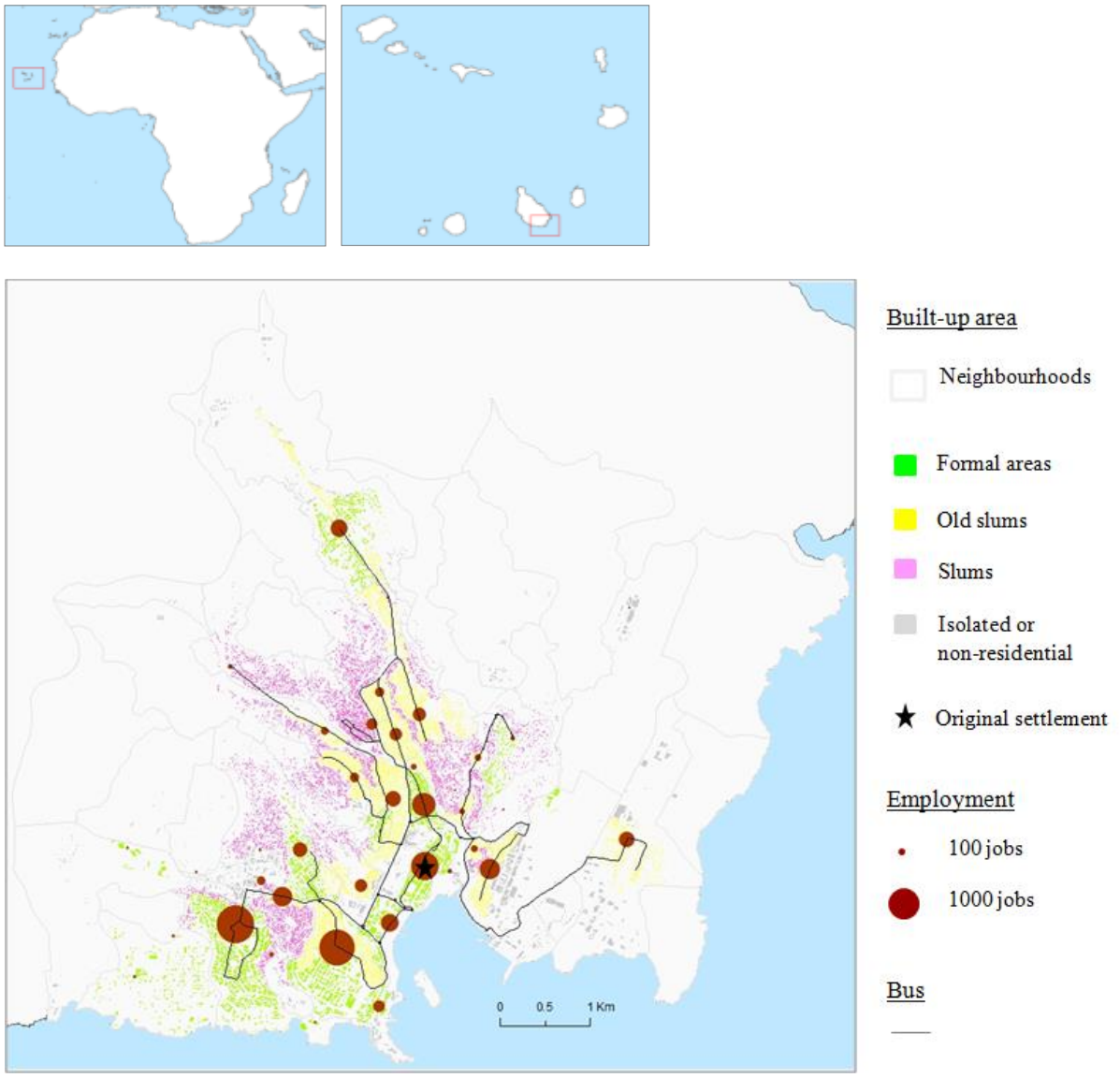
Bocarejo and Oviedo 2012 suggest that the evaluation of transport projects should consider the gains in "real accessibility", which include the time and income spent for accessing work places. The economic barriers to transport are related to operational factors in the public transport supply, as formal bus systems lack the flexibility of informal systems in terms of areas covered and routes used. The need to interchange between services and the lack of integrated tariffs can make the system unaffordable to poorer households [Carruthers *et al.* 2005]. There are also social and economic differences in the time restrictions to accessibility, such as the necessity of scheduling and trip chaining [Weber 2003, Dong et al. 2006].

Walking access is also relevant due to the limited spatial coverage of the bus networks. Niyonsenga and Zuidgeest (2014) show that if we assume a maximum walking distance of 500m, the bus system in Kigali (Rwanda) serves only 37% of its potential demand. Despite the health benefits, walking time may be perceived negatively in developing countries, due to the climate, the presence of motorised traffic [De Langen 2005, Mfinanga 2014, Bradbury 2014], collision risk [Tulu *et al.* 2013, Amoako 2014], dust from unpaved roads [Greening and O'Neill 2010] and fear from crime [Oyeyemi *et al.* 2012]. The disadvantages of living far from paved roads identified by Porter (2002) also exist in the peri-urban areas, including the need for women to walk long distances while carrying produce to sell in market areas.

3. Case study: Praia

Praia is the capital and largest city in Cape Verde, a country classified by the World Bank as a lower-middle income economy. Praia had 130,271 inhabitants in 2010, representing 26.5% of the country's population. The top part of **Figure 1** shows the location of the city in the context of Africa and Cape Verde. The bottom part shows the main variables of concern for this study: the built-up area, the location of slums, the distribution of employment, and the coverage of the bus network.

Figure 1: Context



Notes: Data on neighbourhood borders and buildings provided by the municipal government. Classification of areas according to the Municipal Master Plan [CMP 2013]. Employment data by neighbourhood provided by the National Statistics Office. Bus network data obtained from the bus operator and field work.

For 450 years, the city was limited to a small plateau near the port. Since 1960 the population has increased at an average annual rate of 3.4%, leading to the occupation of nearby plateaus and hills. Slum areas occupy 80% of the urban space [CMP 2013], but older slums are partly integrated with the formal parts of the city and have access to some infrastructure. The most recent slums are located in the periphery or in areas with high environmental risk [Lima 2012, Monteiro *et al.* 2012] and have little employment and infrastructure [Furtado 2012].

The original settlement still concentrates many jobs, as it is the location for administrative buildings, hospital, and schools. However, the main centres of employment are two

neighbourhoods in the west, which are also the largest formal residential areas in the city. Peripheral areas have little employment.

All points of the city can be reached within 30-45 minutes by car. However, according to the 2010 census, only 19% of the households have a private vehicle. The figure varies between 2% and 89%, in the least and most affluent neighbourhood of the city respectively. The ten existing bus lines do not cover the whole city, and according to 74% of the respondents in a 2009 survey, are not well distributed among the different parts of the city [Lopes 2009, p.114]. Informal public transport (shared vans) is illegal but residents in the northern suburbs make use of vans that link the Praia city centre with other towns in the island. Taxis are sometimes shared by low-income workers travelling to the centre [Pólvora 2013], as the price of a ride (CV$150) is not very high comparing with that of a bus ticket (CV$39).

Economic aspects limit access to the bus network, as one ticket is only valid for one trip and costs about 10% of the daily income of workers receiving the monthly minimum salary. The existence of direct bus connections between homes and jobs is therefore crucial in the determination of job accessibility of low-income households. Walking access to the system is also relevant, as some areas in the outskirts are located at a distance of several km from the nearest bus stop. Walking is restricted by the hot, dry climate, by the location of the neighbourhoods in hills and plateaus, and by the increasing concern about crime [Pina *et al.* 201, Zoettl 2014].

4. Preliminary analysis

This section reports the results of a survey to 163 residents of the city. The objective was to obtain a general understanding of the accessibility issues for the population and of the perceptions of individuals in different groups in society and living in different parts of the city. The survey was done in November 2013. Respondents were stopped on the street and asked to answer a small multiple-choice questionnaire and to state the neighbourhood where they live. Recruiting was done across the city in order to obtain a number of respondents proportional to each neighbourhood's adult population. Within each neighbourhood, people were stopped randomly. **Table 1** reports the percentages of respondents in each income group, qualification levels, and usual means of transport choosing each option. The cut-off point for the lowest income group is near the minimum wage in Cape Verde of 11,000 CV$/month (€100).

Table 1: Mobility and accessibility, by income, qualifications and mode of transport

	Income (10,000s CV$/month)				**Qualifications**			**Usual means of transport**				
	0-1	1-2	2-5	>5	Low	Med.	High	Car	Taxi	Bus	Van	Walk
N	45	46	39	33	33	98	32	8	14	96	28	17
Usual means of transport												
Car	0	0	0	24	0	2	19					
Taxi	7	11	3	15	9	10	3					
Bus	62	57	64	52	42	59	75					
Shared van	20	17	26	3	36	15	3					
Walk	11	15	8	6	12	13	0					
Reason												
Financial	49	48	56	36	52	47	48	25	29	63	14	47
Travel Time	11	15	13	15	15	13	13	13	29	6	29	18
Schedule	9	4	8	9	9	8	3	13	7	5	18	0
Comfort	4	4	10	24	12	7	16	50	14	3	21	12
Availability	27	22	10	9	12	21	13	0	21	17	18	24
Route	0	7	3	3	0	3	6	0	0	5	0	0
Daily return trips to city centre												
<1	31	39	36	36	45	33	34	13	36	39	29	41
1	40	43	38	21	36	41	25	25	29	32	50	53
2	11	11	18	21	9	16	16	38	7	17	11	6
3	16	4	8	18	6	9	22	25	21	11	7	0
4 or more	2	2	0	3	3	1	3	0	7	1	4	0
Limitations to travel by public transport from area of residence?												
Yes	47	43	38	30	55	59	66	13	29	42	37	65
No	53	57	62	70	45	41	34	88	71	58	63	35
Why?												
Low Frequency	52	45	60	80	40	65	45	100	75	55	40	64
No bus line	48	55	40	20	60	35	55	0	25	45	60	36
Opinion price bus												
Very High	47	25	10	21	26	27	25	13	29	31	13	19
High	19	18	38	39	26	24	41	38	21	28	38	26
Reasonable	35	57	49	39	48	49	31	50	50	40	50	56
Low	0	0	3	0	0	0	3	0	0	1	0	0
Opinion price shared van												
Very High	18	11	8	12	19	13	3	0	21	11	14	12
High	25	11	21	15	13	18	23	25	7	20	14	18
Reasonable	57	77	72	73	68	68	74	75	71	67	68	71
Low	0	0	0	0	19	13	3	0	21	11	14	12
Opinion price taxi												
Very High	27	11	10	18	12	16	23	0	7	25	7	0
High	31	29	23	45	24	27	32	25	14	27	29	35
Reasonable	42	60	67	36	64	57	45	75	79	47	64	65
Low	0	0	0	0	12	16	23	0	7	25	7	0

Notes: N=163. Values are percentages of respondents in each group. Qualifications: High: <4 years of formal education, Medium: 4-12 years, High: >12 years. Values for walking include cycling (reported by one respondent).

Buses are the main means of transport for all income and qualification groups, with shares considerably higher than the ones in other African cities, which are usually below 10% [ATPP n.d.]. Shared vans and walking occupy in the second and third position for all groups, except for the highest income and qualification groups, for whom cars are the second most important means. Cars are used by only 2% of respondents in the medium-qualified group and by no respondents in the low-qualified group and in all income groups except the highest. An important proportion of people use taxis, especially in the case of the high income group.

Financial aspects are the main reason for the choice of means of transport of all groups, although they are less relevant for the highest income group. The availability of transport is the second reason for the two lowest income groups. The proportion of respondents reporting this reason in these income groups is more than double of the one of two highest income groups. Financial aspects are by far the most important reason for respondents using buses. Respondents using vans consider a variety of reasons, but travel time is the most frequent.

A substantial proportion of respondents in all groups (except the group of people who walk) make in average more than one daily return trip to the city centre. This is especially the cases of people with the highest income and highest qualifications and of car users. In contrast, the proportion of respondents making less than one daily return trip is higher for the lowest qualification group and for people who walk.

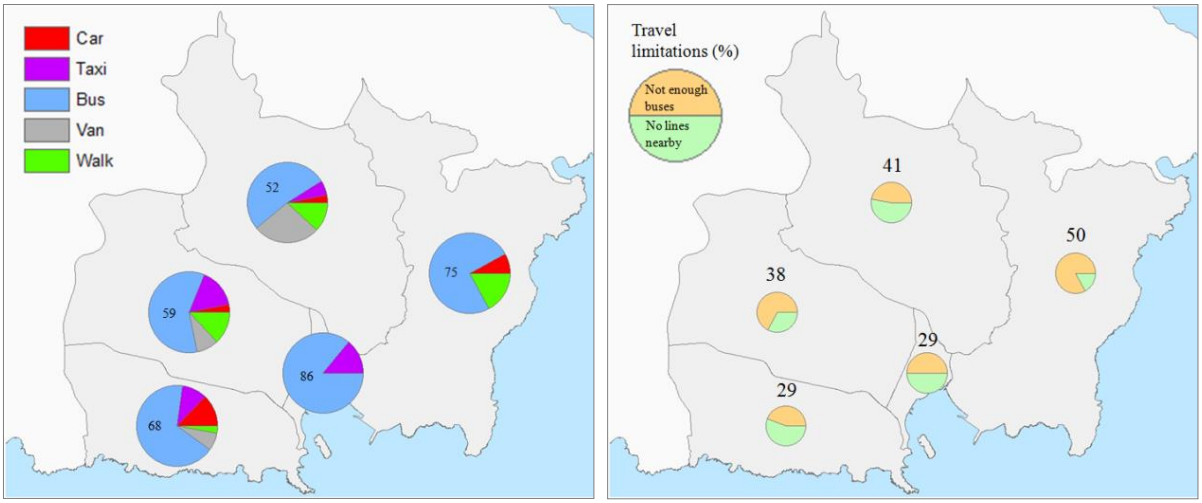
The proportion of respondents reporting limitations to travel by public transport from their area of residence decreases with income but rises with qualification levels. Two options were given to the respondents reporting limitations: insufficient bus frequency and inexistence of services nearby. The proportion of respondents reporting the inexistence of services is higher for individuals in the two lowest income groups, with low and high qualifications, and using vans and buses.

The economic restrictions to accessibility were measured by perceptions about the prices of the three available public transport options: bus, shared van, and taxi. The proportions of respondents perceiving these prices as high or very high decrease with income, but not with qualification levels. Buses are perceived as especially expensive by the lowest income group, comparing with the prices of shared vans and taxis.

Figure 2 maps the variables that are related to geographic factors. The values are grouped according to the five planning units defined by the municipal government. The use of buses is highest in the central part of the city and less important in the north-western and northern zones, due to the higher relevance of taxis and shared vans respectively. The proportion of

respondents reporting public access limitation is lowest in the central zone and in the densely populated western zone and highest in the sparsely populated eastern zone. Service frequency is the main limitation in the north-western and eastern zones and the lack of bus lines is more important in the northern and western zones.

Figure 2: Main means of transport and existence of travel limitations, by zone



Overall, the results show the importance of the bus system to the accessibility of the population, especially in the case of low-income groups. These groups rely on buses to a larger degree than more affluent groups and report more limitations in accessibility in their areas of residence, higher concern about availability of public transport, and higher sensitivity to financial factors. Shared vans and taxis are used as an alternative to buses in some parts of the city. Travel time is relatively unimportant, especially for lower income groups. The design of the analysis that follows makes use of these insights, by measuring job accessibility in terms of the number of bus trips required to access workplaces (as this number impacts on travel cost) and in the walking time to access the network (to account for the inexistence of services in some areas of the city).

5. Bus accessibility and spatial equity

This section analyses the number of formal jobs reachable by bus, for alternative hypothesis about the number of bus trips and walking times to bus stops. The analysis considers the jobs reachable with 0, 1 and 2 bus trips and with a maximum of 5 of 10 walking (to the workplace or to bus stops).

The modelling of private sector employment was based on data provided by the National Statistics Office, from the 2011 census of private companies. This data lists the names,

addresses and sector of activity of all the private companies in the city. A separate data set provides the total number of employees in the city in each sector of activity. This number was split equally by the number of companies in that sector. Corrections were then made to account for employment in large companies, using information obtained from the companies and from documents published by the Praia municipal government. The addresses of the companies were in many cases incomplete, indicating only the neighbourhood. However, information on the exact location of companies in the services sectors within each neighbourhood was available from fieldwork done for a previous study [Nascimento 2009]. The locations of jobs in the agricultural and industrial sectors were assigned to the areas in the neighbourhood more likely to accommodate those jobs.

The location of public sector employment was based on information in the Praia municipal master plan [CMP 2011, 2013] and in the fieldwork done for the study cited above. The number of employees in each institution was given by documents published by these institutions and by the national and municipal governments.

The optimal bus routes between each pair of bus stops are defined as the ones with the smallest number of interchanges. It was found that no routes require more than one interchange. The optimal route from home to work is the one that minimizes total walking time to and from bus stops for the route that minimizes the number of interchanges. In the determination of whether a job can be reached, the maximum walking times of 5 or 10 minutes applied at both origin and destination.

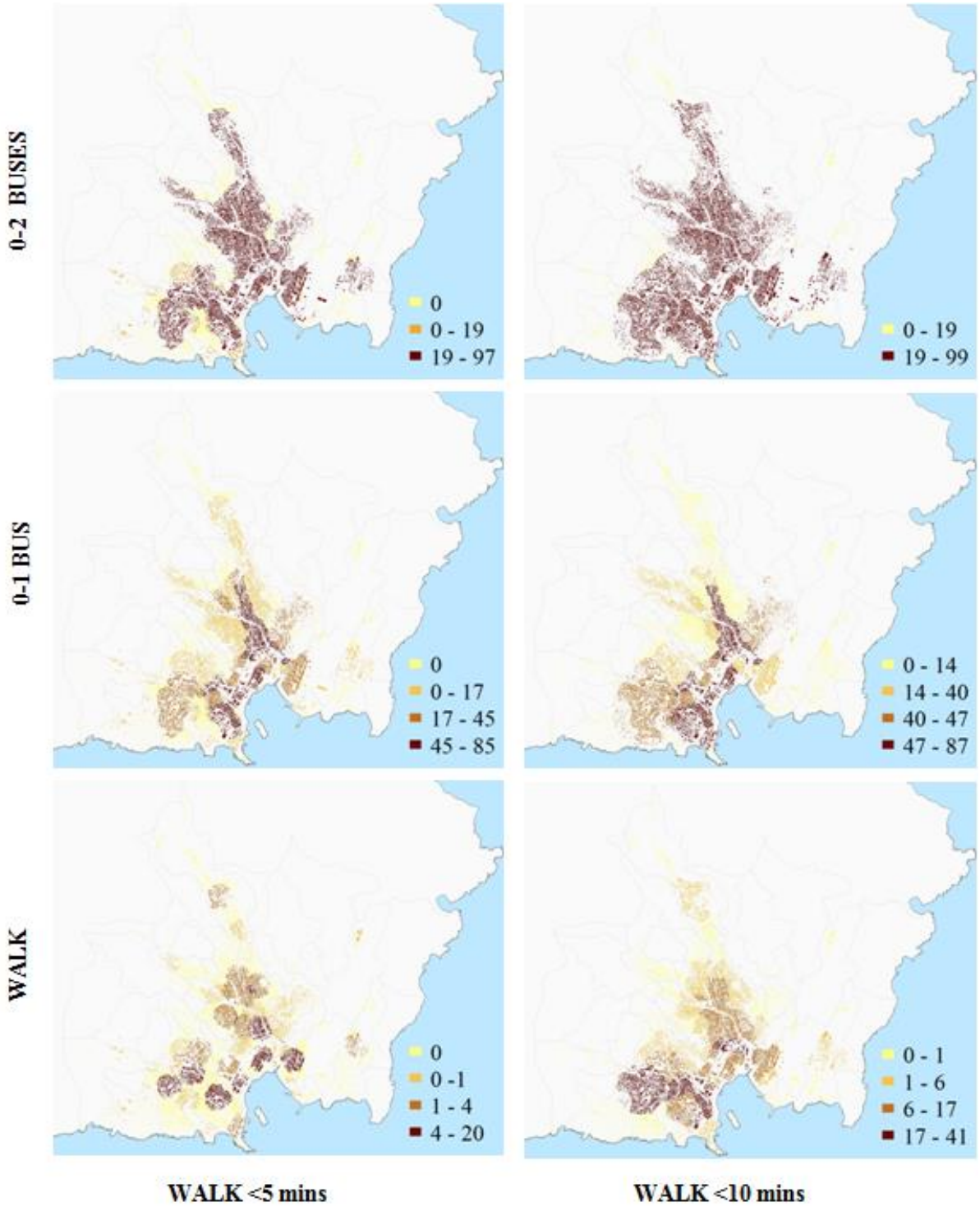
The estimation of the optimal walking routes from home or workplace to bus stops took into account two factors. The first factor is the space available for pedestrians. This is relevant in cities in developing countries due to the high proportion of informal areas. The space available for pedestrians in these areas is wider and allows for more direct routes than in formal neighbourhoods, where movement is limited to pedestrian pavements and formal road crossings. The space available for pedestrians is then defined as pedestrian pavements and road crossings in formal roads and streets (given in a dataset provided by the municipal government) and all public space in informal areas.

The second factor is the influence of slopes on walking speed. This factor is particularly relevant in the case of Praia, as the neighbourhoods occupy plateaus and hills. The estimation of walking speed used the formula proposed by Van Wagtendonk and Benedict (1980), with the parameters used by the Global Map of Accessibility research project [Nelson 2008]:

$$Speed(km/hr) = 5 * e^{-3*[Slope]}$$

The proportion of jobs reachable by bus was calculated for each building. The data with the location of the buildings was provided by the municipal government. **Figure 3** shows the results obtained for each hypothesis about the maximum number of bus trips and walking time to access workplaces. The values are classified according to quantiles of distribution.

Figure 3: Proportion of jobs reached, by walking time and number of bus trips



The distributions of the proportion of jobs accessible directly by walking are different for the two walking times thresholds. When the walking time is under 5 minutes, the areas around the central parts of the neighbourhoods are the most accessible. This is due to the usual pattern of concentration of employment in these centres, which are surrounded by residential areas. The exception is the original settlement of the city, which is highly accessible as a whole, since its residential function is small and public institutions and companies are equally distributed through all the streets of the neighbourhood. When the maximum walking time is 10 minutes, the neighbourhoods with the highest number of jobs (the neighbourhoods to the west and north of the original settlement) are the most accessible. The original settlement is not in the first quartile of distribution of accessibility. For both walking time thresholds, the areas with the lowest accessibility are the ones of more recent settlement, at the fringes of the city. However, a small cluster of buildings in the North have relative high accessibility comparing with other peripheral areas.

When considering single bus trips, the areas with highest accessibility are the original settlement and an inverted L-shaped pair of transport corridors linking that neighbourhood with the northern and western suburbs. This pattern reflects the position of the original settlement as the transport hub where all bus lines converge. The two maps, particularly the one for the walking time of 10 minutes, reveal the disadvantage of the northern and eastern suburbs, confirming the results given by the survey, which indicate that these are the areas with highest limitations to public transport accessibility (right part of **Figure 2**). It should also be noticed that half of the population reach less than 17% of jobs by bus when the maximum walking time is 5 minutes, and less than 41% of jobs when walking time is 10 minutes.

When allowing for one bus interchange, only the population in the most peripheral areas do not reach a high proportion of jobs. However, when the maximum walking time is 5 minutes, small clusters of neighbourhoods at the fringes of the western neighbourhoods are also at a disadvantage.

The equity of the system can be assessed by relating the characteristics of the populations and the proportion of jobs they can be reached by bus. **Table 2** shows the correlations between demographic and socio-economic variables calculated from the 2010 census and the average proportion of jobs reached in each neighbourhood.

Table 2: Correlations between the proportion of jobs reached and census variables at neighbourhood level

Number of buses	0		0-1		0-2	
Max walking time (mins.)	5	10	5	10	5	10
Activity rate	-0.31**	-0.33**	-0.54***	-0.49***	-0.39***	-0.33**
Unemployment rate	-0.28*	-0.26*	-0.11	-0.05	-0.21	-0.13
Average income	0.71***	0.53***	0.32**	0.39***	-0.09	-0.17
Prop. low income	-0.47***	-0.17	-0.18	-0.23	0.19	0.31**
Income support (State)	-0.11	0.01	0.22	0.12	0.31**	0.32**
Income support (Family)	-0.31**	-0.11	-0.03	-0.05	0.16	0.17
Illiterate	-0.55***	-0.32**	-0.16	-0.23	0.08	0.07
Car ownership	0.63***	0.42***	0.16	0.25*	-0.18	-0.21
Informal building	-0.22	-0.21	-0.20	-0.08	-0.37**	-0.33**
Comfort	0.77***	0.59***	0.42***	0.45***	0.11	0.05
Prop. very low comfort	-0.62***	-0.52***	-0.51***	-0.42***	-0.51***	-0.43***
Large families (>5)	-0.65***	-0.60***	-0.54***	-0.56***	-0.06	0.03
Couples with children	-0.40***	-0.47***	-0.58***	-0.49***	-0.51***	-0.42***
Single parents	-0.61***	-0.52***	-0.21	-0.33**	0.19	0.21

Notes: N =41. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Socio-economic and demographic variables were calculated from census data. Low income: <10000 CV$/month. Comfort level is a composite index included in census data, based on a principal component analysis of variables measuring housing conditions and access to basic services.

According to the spatial mismatch hypothesis, unemployment rates are negatively related with accessibility. The results in the table suggest this is true for the case of direct walking access to jobs, although the associations between unemployment rate and the proportions of jobs reached are only significant at the 10% level. The associations with the other indicators are also negative but insignificant. In contrast, the associations with the activity rate are negative and significant for all indicators.

In general, neighbourhoods with higher economic deprivation and proportions of disadvantaged populations reach fewer jobs. Accessibility tends to be positively associated with average income, comfort, and car ownership and negatively associated with the proportions of illiterates and households depending on support from family members, living in informal buildings and having very low indicator of comfort. However, only this last variable has significant associations with all six indicators of accessibility. The proportion of households with low income is negatively and significantly associated with walking access to jobs but positively associated with bus access when interchange is allowed. The proportion of households depending on state benefits is also positively associated with bus access allowing interchange.

Accessibility is also significantly related with family structure. In particular, the proportion of couples with children is negatively related with accessibility for almost all the indicators. The proportions of large families and of single parents are negatively related with the proportion of jobs reached by walking or with a single bus trip.

Another way to approach the question of spatial equity is to look at differences in accessibility between slums and formally planned areas. This approach is able to account for differences within neighbourhoods, as the indicators of accessibility were calculated at the level of each building and data is available with the borders between those areas, given in maps in the Praia municipal master plan. These maps also distinguish between slums and old slums, which have access to some of the infrastructure also provided in formal areas.

Table 3 show the average proportions of the jobs reached from buildings in the three types of areas: formally planned, old slum, and slum. Isolated buildings scattered across the neighbourhood, and not integrated in any cluster of buildings, are treated separately. The table also shows the city-wide ratios between the jobs reached in slum areas and in other areas and the maximum and minimum values of the ratios in the neighbourhoods which contain both slums and old slums or formal areas. **Figure 4** maps the values of these ratios, for the case of the single bus trips and 5-minute walking time thresholds.

In average, slum dwellers can access only 1% of the jobs available in the city by walking directly to the workplace, if the maximum walking time is 5 minutes. This value is less than one quarter of that of residents in formal areas. The disadvantage occurs in all neighbourhoods. In the most extreme case, slum dwellers access only 3% of the jobs accessed in formal areas. Slum dwellers are also at disadvantage in terms of the other five indicators, both when comparing with residents in formal areas and in older slums. The disadvantages are more severe for smaller number of bus trips and for the smaller walking time threshold.

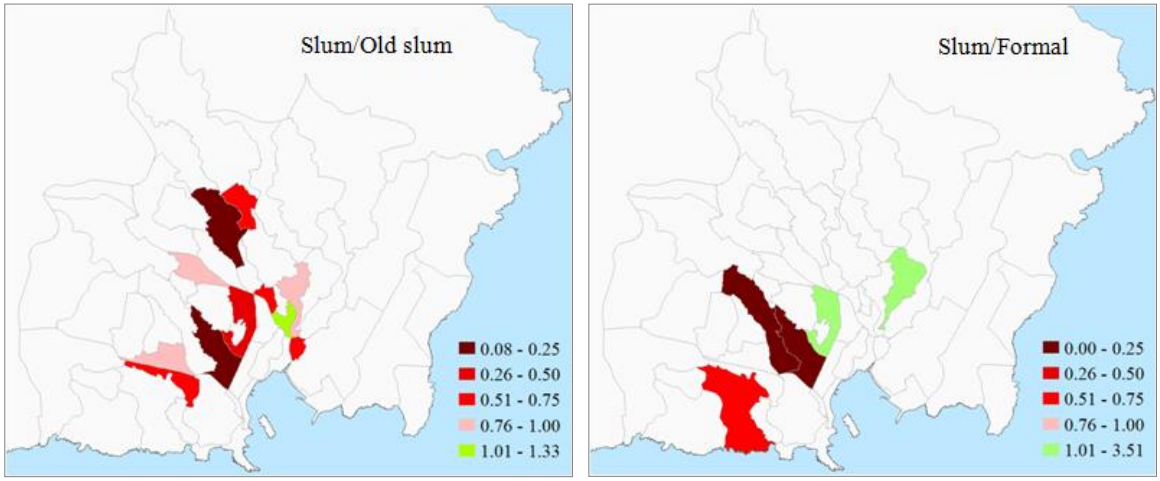
The left side of **Figure 4** shows that there is only one neighbourhood where slum areas are more accessible than old slums, when considering a maximum of one bus trip and 5 minutes walking time to access bus stops. The relation between accessibility of slums and formal areas is more variable, as slum areas are at an advantage in two out of the three neighbourhoods where these two types of areas coexist.

Table 3: Jobs reached in slums (relative to other areas)

Number of buses	0		0-1		0-2	
Max walking time (mins.)	**5**	**10**	**5**	**10**	**5**	**10**
Proportion of jobs reached						
Formal	4.2	11.2	25.8	37.4	68.5	95.7
Old slum	2.8	9.0	28.8	33.0	88.5	98.0
Slum	1.0	6.3	18.3	26.2	61.6	93.3
Isolated	1.0	6.6	18.5	24.8	52.9	80.0
Ratio slum/old slum						
City-wide	0.35	0.70	0.64	0.79	0.70	0.95
Neighbourhood (Min.)	0.10	0.13	0.01	0.06	0.02	0.20
Neighbourhood (Max.)	2.54	2.14	1.64	1.10	1.21	1.00
Ratio slum/formal						
City-wide	0.23	0.56	0.71	0.70	0.90	0.97
Neighbourhood (Min.)	0.03	0.11	0.01	0.15	0.02	0.20
Neighbourhood (Max.)	0.65	1.47	3.51	1.49	1.09	1.00

Notes: N =41. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level;

Figure 4: Ratio between jobs reached in different areas of same neighbourhood



Notes: Access to jobs considering a maximum of 1 bus trip and 5 minutes walking time to access bus stops.

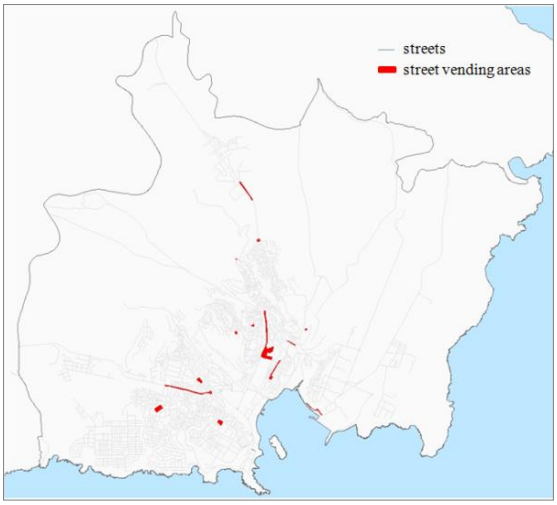
6. Informal employment and competition

The analysis on the previous section was based on access to formal employment. In the context of a developing country, it is also necessary to consider informal employment, especially when focusing on the accessibility problems of populations with low income and living in slum areas. The livelihoods of these groups also depend on the competition for opportunities for informal employment, such as access to space to engage in self-employment. Bus access provides an advantage. For example, a study in Conakry [SITRASS 2004] found

that independent merchants who use public transport to work in the city centre earn on average 28% more than those who work close to home, after transport costs are deducted.

This section analyses the accessibility to areas used for informal trading, one of the most important activities for economically-deprived populations n developing countries, especially for females. The lack of access to spaces for street vending decreases the viability of this activity. The tendency for the formalization of space in central parts of Praia has had an impact on the livelihoods of traders who used the streets in these areas, and led to social tensions [Pólvora 2013]. There is also competition for space in other areas. There is a central market in the central part of the city and six smaller markets in the neighbourhoods. However, vendors also use public spaces in other areas, including squares and areas near busy roads and roundabouts. **Figure 5** shows the locations of the markets and the main areas for street vending in the city. The identification of these areas was based on local knowledge.

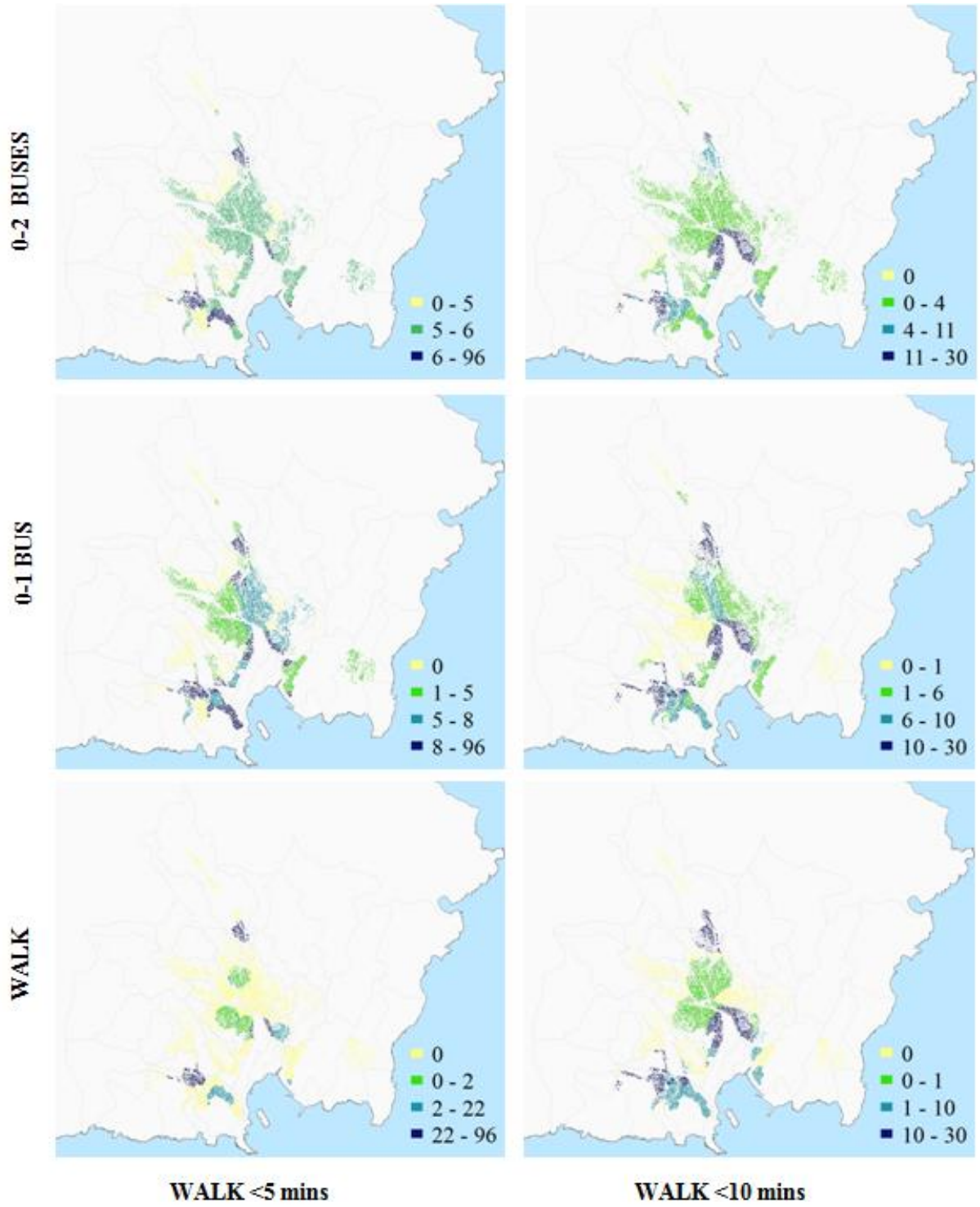
Figure 5: Markets and locations used by for street vendors



The objective of the analysis to map accessibility levels of female residents in slum areas for different assumptions about the number of bus trips and walking time. There are two differences in relation to the approach used in the last section. The first difference is that job opportunities are not measured in terms of number of formal jobs positions, but in terms of area available for street trading. The second difference is that the area that is accessible from one building is divided by the number of all female slum dwellers that are also able to reach that area. The values estimated for each building are then the sum of the personal shares of that resident in all the areas for street vending that she can access.

The results are given in **Figure 6**. Accessibility is only calculated for buildings in slum and old slums. For this reason, there is no cluster of high values surrounding the central market, as this market is located in a formally-planned area and beyond the walking time threshold of 10 minutes from slum areas.

Figure 6: Personal shares of street vending areas reached, by walking time and number of bus trips (m^2/person)



The majority of the buildings in slum areas do not have access to a street vending area within 5 minutes walking. Even when considering a walking time threshold of 10 minutes, about a quarter of the buildings are outside the accessible area. The map for the time threshold of 10 minutes shows that the slum areas at an advantage are those near the geographic centre of the city, located in hills around the functional centre, where the larger markets are located. The slums near the populated neighbourhoods in the west and one slum in the north also have high accessibility.

The slum areas in the geographic centre are also the most accessible when considering bus accessibility. Peripheral areas are at a clear disadvantage, as their levels of accessibility are a small fraction of those of the most accessible areas. The patterns obtained for the indicator based on single bus trips is broadly similar for the two time thresholds. In the case of the indicator allowing interchange, the spatial inequalities are more visible for the longer walking time thresholds.

Overall, the results show that some of the patterns of inequality found for the case of formal employment also apply in the case of informal employment. Slum areas closer to formal areas tend to be more accessible than those occupying whole neighbourhoods and than the more recent slums located in the peripheral parts of the city.

7. Priorities for extension of the bus network

A way to evaluate projects to expand the coverage of the transport network is to estimate the number of potential extra matches between people and employment opportunities that would occur if bus services were made available to population who currently cannot or do not access the service, because of the inexistence of bus services within walking distance or connecting directly their area of residence with the areas where they seek formal or informal employment.

This question can be approached by assuming that individuals do not use a bus to reach a workplace if it involves walking more than 5 minutes or taking more than one bus, but would do so if the walking time was reduced or the trip was direct. The matches between people and jobs or informal trading areas that are currently only possible by making two bus trips or walking between 5 and 10 minutes can then be treated as an indicator of the potential gains of expanding the network coverage or the number of network connections in the areas where those people live.

The maps in **Figure 7** shows the matches between people and jobs, considering trips that at the moment involve two buses or 5-10 minutes walking times to bus stops. The values were aggregated to each type of sub-neighbourhood (formal, slum, and old slum) in each neighbourhood and then divided by area (in m^2), to adjust for different sizes. The areas where the highest density of matches occurs differ in the two maps. In the case of trips involving two buses, the highest density of matches occur in the geographic centre of the city, but in the case of trips involving 5-10 minutes walking time, the highest values occur in the western part of the city, which already have the highest concentration of jobs. The westernmost neighbourhood, a newly built affluent neighbourhood not yet covered by the bus network does not have a bigger density of matches when considering both indicators, as the neighbourhood is also sparsely populated.

Figure 7: Density of matches between workers and jobs

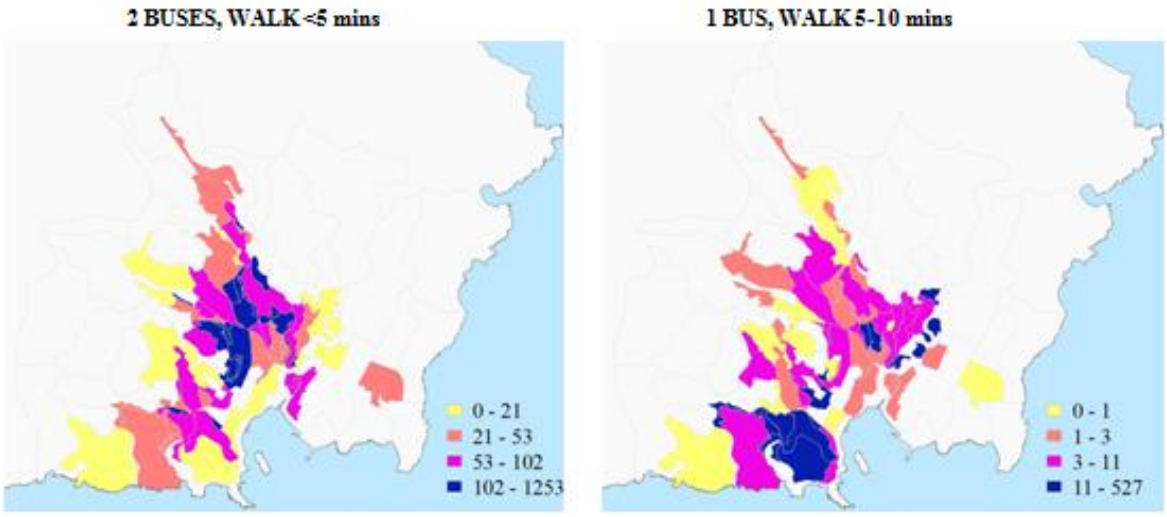


Figure 8: Density of matches between female slum dwellers and area for street vending

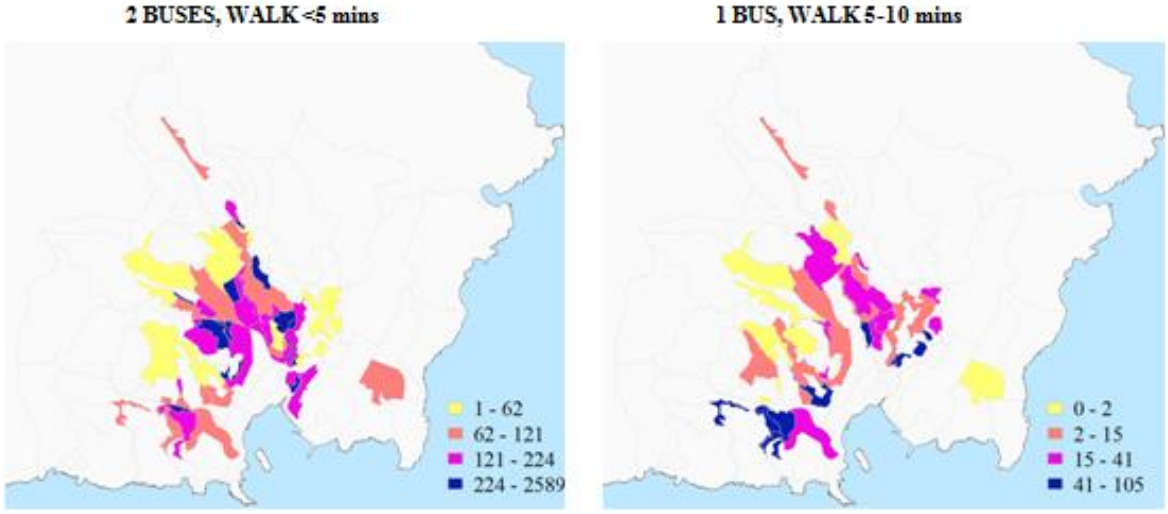


Figure 8 shows the density of matches between female slum dwellers and area for street vending. The distribution of the areas with the highest potential matches is broadly similar to the one with the highest matches for formal jobs depicted in the previous figure, especially in the case of trips involving 5-10 minutes walking time, where the highest gains are in the slum areas in the western neighbourhoods.

The comparison of these two figures with the maps in **Figure 3** and **Figure 6** reveals that the areas at the highest relative disadvantage, in terms of the proportion of job opportunities not reached, are not the ones where the highest potential gain, in terms of absolute gain in the number of matches between people and job opportunities if the bus system became more available for residents who at the moment need to walk more than 5 minutes or take two buses to reach potential destinations. On the contrary, the areas with the highest gains are the ones where a relatively high proportion of job opportunities are already accessible.

7. Conclusions

This paper evaluated the extent to which the bus system provides access to formal and informal employment to deprived populations in a city in a lower middle-income country. It was found that these populations are at disadvantage especially when considering direct bus connections to jobs. The extent of these disadvantages varies across the city. Slum areas in the geographic centre of city are at an advantage in the accessing to both formal and informal employment. The areas at highest disadvantage, in recently occupied slums in the periphery, are not the ones bringing highest gains in terms of potential matches between people and jobs, which occur in densely populated formal areas and in geographically central slum areas.

The study provides insights on equity issues arising in a relatively small city with high income disparities and with limited public transport supply. The expected growth in average income and the current financial difficulties of the bus operator do not provide the necessary conditions for the investment in the expansion of the bus network. Nevertheless, as population grows and the city expands, the disadvantages faced by individuals living in peripheral areas and with no access to private vehicles become more severe, contributing to the exclusion from the opportunities offered by the city. Public investment in the bus system may then be justified with its impact on equity. The regulation of informal public transport, which is already used by a fraction of the population as an alternative to the bus system, and land use measures to promote a more equal distribution of jobs within the city are two alternatives for breaking the links between poor accessibility and social exclusion.

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