Accessibility and urban environment sustainability in Sydney (1991–2001)

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Abstract

One of the most important issues for enhancing environmental quality, especially in the urban environment, is developing accessibility versus mobility. With regard to this, we calculated the accessibility indicator by a zonal opportunity gravity model (employed person) for 38 local government areas (zones) with GIS tools, and, in addition, the changes in accessibility measured during 1991–2001. In addition, the relationship between the accessibility index and six sub socio-eco-physical factors was calculated by multiple regressing. The result yielded from a map of accessibility changes shows that two scenarios had taken place simultaneously. One is a high positive change of accessibility value both in the central core, mostly strap pattern (concentration) and sub-urban areas (decentralization), the other is the low positive or negative change of accessibility value in the middle rings of Sydney. The results achieved by calculating the relationship between the accessibility index and the socio-economic variables show that zones that have low car usage to work have high accessibility value. In contrast, zones with low weekly income families, far from the city center, with a high percentage of car usage to work have a low accessibility value.
Keywords: accessibility, Local Government boundaries, urban environment, sustainability.

1   Introduction

Accessibility has been argued about for over half of century, especially from the publication of the Hansen quantity method about accessibility (Hansen, [17]). The predominance of extensive sub-urbanization after World War II (1939-45)

and the vast use of cars for commuting between work and housing locations in the urban region (Newman et al. [16]). The energy crisis in the 1970s (significant rise in oil price initially in 1973 (Anna V.Gollner, [18]) and environmental concerns changed opinions from mobility to accessibility in urban and transportation planning and design, for example in Australia the planning of cities in the late 1970s and early 1980s was largely driven by resource conservation issues and the growing concerns of social equity issues (Anna Gollner, [19]). Some of cities similar to Vancouver in Canada (Newman et al. [16]) have used the principles of accessibility planning in urban planning and design.

   Accessibility is defined as "the freedom or ability of people to achieve their basic needs in order to sustain their quality of life" (Nil Pasaogullari et al. [21]). Accessibility is basically divided into two types, that is, "relative accessibility" and "integral accessibility" (R.C.W. Kwork & A.G.O. Yeh, [20]). Therefore accessibility can generally be defined as the ease in reaching a place that is considered attractive. This definition implies the common inclusion of two components in the measurements. They are the land-use pattern and performance of the transport system. For the land use pattern, the more opportunities within a region, the higher the accessibility (hence total employed persons in the region is the pull power of attraction). For the performance of a transport system, the less impedance distance (time travel, cost) between a given point and its opportunities, the higher the accessibility. Here the spatial distance between points (center of local government boundries-38 L.G.B) is calculated.

2   Purpose of research

1-To calculate accessibility and its changes in Sydney during 1991 to 2001, 2-Measuring the relationship between the accessibility index and 6 Socio-eco-physical sub groups (16 variables).

3   Research model (hypothesis)

Figure 1 shows the process of research (hypothesis) and interaction between socio-eco-physical variables and accessibility index and it's feedback.

4   Socio-eco-physical factors

For achieving this research 6 factors have been used, each of them including several variables as follow: Population variables, dwelling variables, income variables, employment variables, transportation variables, and geographical variables.

5   Research methodology

5.1   General formulation

The following model is selected with regard to the data available:

$$\sum_{j=1}^{N} T_{i1,2} = \sum Sj/_{di\,j^a}$$

$T_{i1,2}$= is a relative measure of the accessibility of zone 1 to an activity located within zone 2

S_j= Size of activity at zone 2, e.g. the number of jobs, people, etc (here is the people employed in 1991 and 2001)

D_{ij}= is the travel time, distance or cost from zone i to zone j
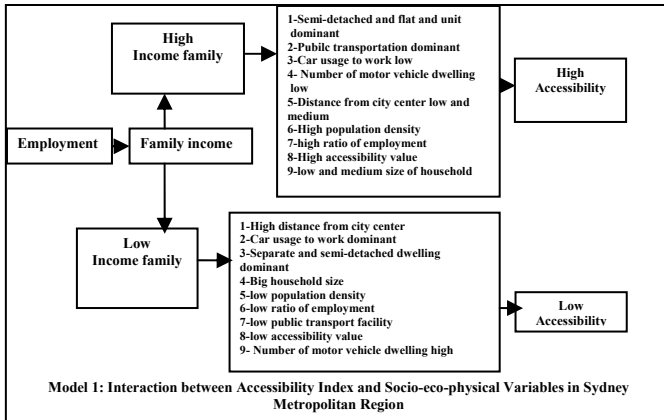
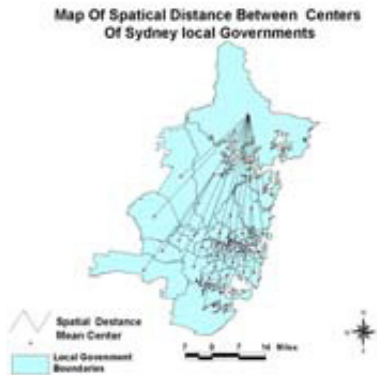a=parameter and equal 2

Figure 1.

Figure 2.

5.2 Measuring interaction between zones

At the first distance among zones (d_{ij}) is calculated by using Arc.view (GIS) option means center. Then, for measuring the interaction among zones, the

distance between zonal centers has been used (38×38 matrix of local government mean center). A sample point has it's distance calculated from other zones in figure 2. After calculating the distance between zones, the interaction between them should be measured, in this stage by using the above gravity equation and entering the total employed persons aged 15 years and over from ABS 1991 and 2001 (Australian Bureau statistics [1,2]) to the model as s_j and distance between zones as d_{ij}, the background for calculating interaction between zones and sum of each T_i provided.

6   Overview of Sydney

Sydney is located at latitude 35° south (Mike, [9]) and in New South Wales (NSW) state of Australia. This metropolitan had almost 63.7% total of the population (3997321 persons) of New South Wales 2001 (a.b.c2001). The population of Sydney changed from 3538314 in 1991 to 3997321 people in 2001. The percentage of change during this period was 13.1% and it is predicted that the population growth of this city will reach 5 million by 2022 (D.I.P, NSW, 2002). Mean household size of this city was 2.7 people in 2001. This city is the most important one in Australia and it has the biggest economy in the country, equivalent to Singapore and bigger than New Zealand (D.I.P.R, NSW, 2002). Labor force numbers in Sydney had changed from 1556448 people (89.7% employed of labor force) in 1991 to 1916223 person (93.9% employed of labor force) in 2001. The ratio of unemployed during this period reduced from 10.3% to 6.1%. The distribution of employment and population around the Sydney metropolitan region shows spatial difference. The ratio of employment in the central core and inner city is higher than the outer ring (from 70% to 35%). Therefore different travel modes to and from work are created in a metropolitan area. This situation produced more car travel to and from the work location; almost 70% of travel to work was by car, 15% train, 6% bus and 9% other in 1996 (Department of Urban Affairs and Planning, 2001).

Some of the differences in the stages of urban development include; pre and post-war II city development plans (Anna V. Gollner [18]), income family (range of income weekly family in Sydney varied from 500 to 1750 in 20001(a.b.c2001)), concentration of industries (factories), employment caused uneven and inequitable spatial urban morphology for Sydney, that many of researchers (Joan Vipond, et al, 1988) divided the city in three distinct zones: 1-inner Sydney: oldest city and 10 km distance from city center, 2 - middle Sydney located between 10 to 25 km from boundaries of inner Sydney and after World War II around rail road developed , 3 - Outer Sydney .

Urban Sprawl (approximately 12144.6 sq.km^2 and 3997321 persons population density 329.14 people /Esq.km^2) and 1356047 housing (2001) show that the Sydney metropolitan is one of the top 10 most sprawling world metro regions and low population density (Environmental Health [8]). Therefore this city has been faced with the problems of accessibility versus mobility. Also the value of community accessibility in Hong Kong was 99.3 compared with 36.8 in Sydney (William Ross Benvse, [22]). Because of overcoming problems resulting

from mobility, this research was conducted to recognize accessibility and its changes during 1991 to 2001 in the Sydney metropolitan region, and analysis was carried out to determine the influence that factors had on accessibility as follows:
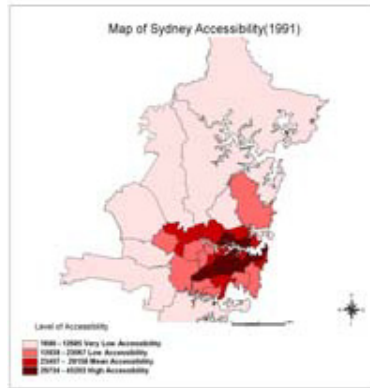

Figure 3.

7 Discussions

7.1 Measuring 1991 Accessibility Index

For measuring accessibility two variables were used. One is distance between the center of statistical trace (local government boundaries in 1991 and 2001), another is the number of employed persons as opportunity (d_j) meager in each zone during this period. The result of this measuring for 1991 accessibility is shown in figure 3.

   The result of the analysis of accessibility in 1991 in Sydney showed that the central core and its fringes is the zone with high and medium accessibility index. The most remarkable feature of this region is the concentration of central business district (CBD) and civic infrastructure (rail, high way, bus, ferry and mono rail and so on). Therefore this precinct has the highest accessibility and especially with regard to public transportation facilities. From the center of the city towards the outskirts of Sydney the gradient of accessibility value decreases.

7.2 Accessibility Index in 2001

The result of this calculation is illustrated in figure 4. With the quartile option of Arc.view all of the zones from the accessibility index are classified in four sub groups 1 - very low (10 zones), 2 - low (10 zones) 3- medium (9 zones) and 4- high accessibility (9 zones). The central core and inner city rings have the highest rate of accessibility similar to 1991 ones. As a consequence accessibility

value decreases by the increasing distance from the city center both in 1991 and 2001.
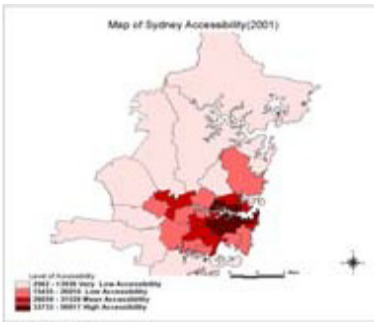

Figure 4.

7.3 Changes of Accessibility Index during 1991 to 2001

Figure 5 shows the result. The mean accessibility change index was 18%, with the minimum change 4% (Blacktown) and maximum change 61% (Strathfild). The related map shows that that two processes take place simultaneously in the Sydney metropolitan region. One is Decentralization of accessibility in sub-urban areas and the other is Concentration (Centralization of accessibility in central core but with strap pattern). A new question can be considered - why decentralization took place?
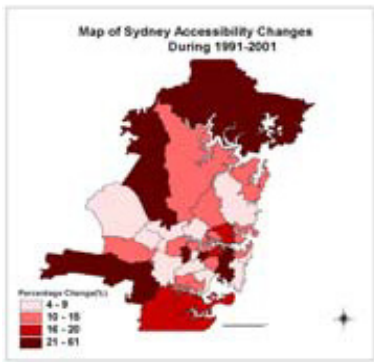

Figure 5.

8   Analysis relations between accessibility index and Socio-eco-physical variables

The coefficient correlation between accessibility indexes in 2001 and 14 variables have been calculated and the results are illustrates as follows:

8.1 Positive relation

This sub group has 4 variables (travel by train and bus to work, number of unit, flat and apartment dwellings, population density, semi detached dwellings). Relationships between these variables and accessibility are positive. That means, zones with a high value in the above-mentioned variables have a high value of accessibility. Therefore they are concentrated in and around the central core.

8.2 Negative relation

This sub group has 10 variables (distance from city center, travel to work by car, percentage separated and semi detached dwellings, mean household family, percentage separated dwellings, percentage of employment, income family, travel to work by train and travel to work by bus and train. The relationship between these variables and accessibility index is negative. That means these zones are located far from the central core in the sub-urban region of Sydney.

9   Conclusion

The results obtained from the application of this model indicate that Sydney from an accessibility standpoint is an un-equal environment, and the city can be divided in four sub-groups as follow:
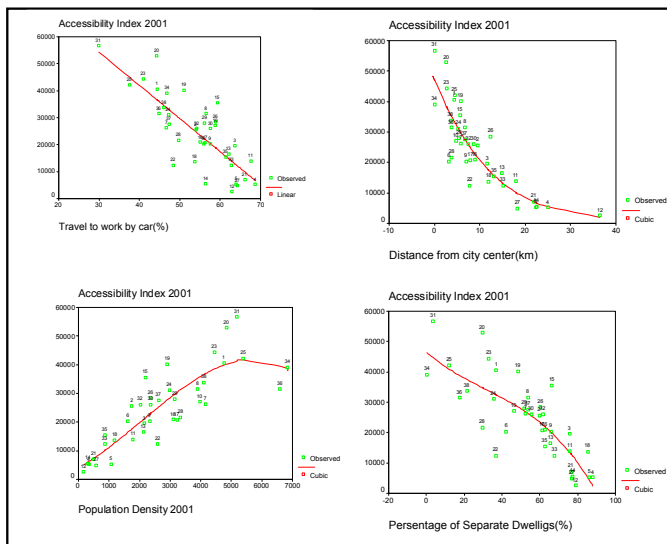

Figure 6:   Relationship between Accessibility Index and socio-eco-physical variables in Sydney (2001).

9.1 Very low accessibility and low income family (more than 8 zones)

These zones are located at the outer fringe of metropolitan area of Sydney (far from the city center). They have a low population density, low ratio of

employment, high car usage for traveling to work and other activities, priority of separated dwellings, low access to public transportation facilities, big household size and low rent dwelling are the important characteristic and remarkable of these zones.

9.2 Low accessibility and high income (more than 6 zones)

These zones have a large household size. Located far from the city center, high car usage, low access to public transportation, and high proportion of separate and semidetached dwelling. The important differences between theses regions with the very low sub group accessibility are that some are high-income families and are a little closer to the city center and have some access to public transportation.

9.3 Low income family and high accessibility (similar Auburn and etc- 7 zones)

More than half on these zones are located in the inner ring of Sydney. They have good potential for future development, but are faced with some problems including; the high rise ratio of unemployment in this region, high population density, low-income family, high usage of public transportation to work and low usage car to travel to work. Spatial distribution and proximity of these zones is low and somewhat dispersed.

9.4 High income family and high accessibility (more than ten zones)

For the most part these zones are located in the inner ring and central core of Sydney. The nucleus initial of urban development and historical concentration of business district in this region to the attendant of concentration of other facilities have caused this zone to become the most important in the city of Sydney. Therefore this region has the highest index of accessibility.

Finally, the initial hypothesis at the beginning of the discussion rejected the direct positive relation between high-income family status and high car usage for traveling to work and hence far from city core location dwelling and high accessibility. Because it was proved that zones with high-income families are not dispersed in the outer suburb of Sydney metropolitan. They are concentrated mostly in the inner ring of Sydney with a medium distance from the city center. Therefore they have good access to the public transportation mode of travel to work. Hence they use a low private mode of travel to work (mostly car usage). Also in the region with low accessibility and low income, many of the residents do not have access to public transport, therefore they prefer to have a car for meeting their needs. Using car in these zones has many advantages including: 1- to decrease transport cost, 2- Access to big house (separated dwelling) with low rent and big household size in the remote suburban areas. Owning a car to provide these direct advantages and to substitute costs of long distance. Therefore there is not direct relation between car usage and family income. Even

in this research after dividing income family groups into three subgroups (low 700-1030, medium 1000-1330 and high 1330-1700AU$) and calculating the relationship of these three groups with car usage by "One Way Analysis "had approved that there was significant difference between the percentage of car usage and sub income groups especially between the first group (low income group -68% car usage) as compared to the third group (high income group-56% car usage).

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