TRANSPORT DISADVANTAGE AND PUBLIC TRANSPORT NETWORK CHANGE: A CASE STUDY OF BELFAST CITY

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ABSTRACT

The effect of transport disadvantage on levels of participation and access to goods and services is a key policy issue in the design of public transport networks. There is a considerable amount of evidence to suggest anecdotally, at least, that the development of metro style bus operations and high frequency corridors can have a detrimental impact on transport disadvantaged groups, especially where service reduction in deprived areas have been experienced. In Belfast, the public transport network has been transformed into a Metro Service, which is dominated by high frequency corridors. The aim of the transformation was to provide better access and target social needs and to minimise the effects of societal inequalities and communal segregation, which the city has historically experienced. This paper using a GIS Model examines the effect of network change on the city and the newly emerging patterns of improved and deprived accessibility that have been experienced as a result. Findings from the GIS model are based on comparisons of the old City Bus network with the newer Metro Service network, and present an assessment of the spatial impact of network change on different social groups in the city through identification of transport deprived areas pre and post network change.

Keywords: Public Transport Network Change, Transport Disadvantage, Social Exclusion

1. INTRODUCTION

Development of Metro networks and high frequency corridors having a detrimental impact can promote transport disadvantages when service reductions in neighbourhood areas are

experienced and where the benefits associated with higher frequencies routes are located at greater walking distances (SEU, 2001, 2003; Tyler, 2002). The public transport network of Belfast city was transformed into a Metro network dominated by high frequency corridors in response to Regional Transport Strategy (RTS) 2012 (Translink, 2004; DRD, 2009). This paper uses network analysis and spatial analysis tools within GIS to examine the effect of network change on the city and studies the newly emerging patterns of improved and destitute accessibility that have been experienced as a result. The paper presents findings from a GIS based comparison of old City Bus with the newer Metro Bus Service, assess the spatial impact of network change on different social groups in the city pre, and post network change. The paper comprise of six sections.

Section 2 elaborates how changes in the transport network can inflict disadvantages and exacerbate social exclusion. Section 3 examines the case of Belfast city that has undergone transport network transformation. Section 4 describes the methodology adopted for the paper. Section 5 presents results. Section 6 concludes with a discussion of key findings and the prospects for future research.

2. PUBLIC TRANSPORT, TRANSPORT DISADVANTAGE AND SOCIAL EXCLUSION

The issue of transport disadvantage and social exclusion is a key policy area in the United Kingdom (UK) transport policy. The Transport White paper by Department of Transport (DfT, 1998) affirms that transport plays an important role in inclusion of individuals within society through better accessibility and mobility (Hine et al., 2003, SEU, 2003). Public transport system imposes negative externalities on social group within communities in form of isolation from jobs, education and training when it does not meet their travel needs. These negative externalities include inadequate public transport, reduced or poor accessibility to basic facilities, adverse impact of road traffic, and travel poverty (Raje et al., 2003; Lucas et al., 2001; SEU, 2003; Church et al., 2003; Nutley and Thomas, 1995). These adverse impacts of transport system lead to segregation and social exclusion of individuals and communities in the society. Social exclusion is a process, which causes individuals or groups not to participate in different activities offered by the society in which they would like to participate due to reasons beyond their control (Burchardt et al., 1999; Preston et al., 2007; Rajé, 2004). The notion of transport disadvantage and social exclusion is different from the concept of travel behaviour and attitude as it includes variables based on socio-economic, demographic, physical and cultural differentiations. These variables affect the travelling patterns of social groups (SEU, 2003; Witter, 2007; Miller, 2005).

Five key barriers serve as the main cause of public transport related social exclusion. These are availability and physical accessibility of public transport, cost of transport, services and activities location, safety, and travel horizons (SEU, 2003; Litman, 2003). A wide set of dimensions related transport disadvantages and social exclusion include physical exclusion, geographical exclusion, exclusion from facilities, economic exclusion, temporal exclusion, exclusion due to safety concerns, space exclusion (Church et al., 2001, 2003; Graffon et al.,

2001; Hine and Mitchell, 2001). Kenyon, Rafferty and Lyons (2003) augmented the work executed by Graffon et al., (2001), Hine, and Mitchell (2001) by defining a new set of dimensions, which included both disadvantages because of transport itself and those in which transport acts as an essential sub-component but has no direct impacts. These included economic, living space, mobility, organized, personal, social networks, and loneliness, societal and temporal. The cumulative effects of these dimensions determine the level of transport disadvantage and exclusion experienced by people and communities (Litman, 2003).

Changes in the public transport network occur due to planning process i.e. transformation (network upgrade), land use, public transport operations, transport infrastructure, key event, critical incident and socio economic variables. Key events are major event in the personal life of an individual such as change in job or location. Key events can be an outcome of a change in transport network. Critical incident are immediate events that occur in daily life such as an accident or temporary closure of a service (Waerden et al., 2003). Critical incident refer to temporal exclusion.

Specific aims and objectives guide the design of a public transport network for optimal performance. Therefore, characteristics of the network are determined by a set of variables that include stop spacing, line spacing, information etc (Tahmassey et al., 2009). Changes in these variables also affect the performance of the transport network, which eventually affects the aims and objectives of the transport network resulting in transport disadvantage.

Three different types of process influence the connections between transport network and level of participation offered by it. These processes include nature of time-space organisation in households, nature of transport system and nature of time-space organisation of the facilities / opportunities individuals are seeking to access. Nature of these processes differs with respect to gender, age, cultural background, level of accessibility and economic circumstances (Hine et al., 2003; Church et al., 2001, 2003). The nature and quality of a public transport system therefore, mainly depends on the configuration of its network (Witter, 2007; Akosy and Gultekin, 2006).

3. THE CASE OF BELFAST CITY

Belfast, the capital of Northern Ireland and fifteenth largest city in United Kingdom has an extensive road network and is highly car dependent as a mode of transport for journey completion. 77% of all journeys in the city were made by car whereas only 11% were made by public transport according to 2001 census (NISRA, 2001). Pedestrians account for 6% in total journeys made by different mode. In 2001, 393 cars per thousand of population were available whereas in 2008 these figures rose to 627 cars per thousand of population, which is high in comparison to other cities in UK (NISRA, 2001, DRD, 2009). Census surveys are conducted after every ten years in Belfast city. The last census took place in 2001. Therefore, 2001 census data was used for research purpose. Although there are some midyear estimates but these estimates are made on, higher spatial level i.e. wards. Wards

consist of smaller spatial units. In order to cater the problem of zoning in GIS smaller spatial units were considered.

Belfast has a non de-regulated public transport system, which makes it unique from rest of UK areas where de-regulation took place under the 1985 Transport Act. The Northern Ireland Transport Holding Company (NITHC) solely operates bus and rail public transport services in Belfast under the group name Translink through three subsidiaries Metro Service (formal City Bus), Northern Ireland Railways and Ulster Bus. City Bus started in 1973 operated 60 different routes in Belfast city. The City Bus transformed in to Metro Service in 2005 when 12 quality bus corridors (QBCs) replaced its routes. The 12 QBC are along the main arterial roads into Belfast city centre. The aim of the transformation was to provide better access and higher frequency to facilities so that mode change from private to public transport can be achieved. In addition, the new service was aimed to increase social cohesion in the neighbourhood areas (Translink, 2004, 2005).

Statistics from recent travel survey highlights that network transformation has not been able to deliver its objectives. Car is still the main mode of travelling in the city. Marginal increase of 3 % in the number of people who are able to get a bus from their nearest bus stops every 15 minutes is observed (DRD, 2009). Metro system has been unable to attract a high volume of passengers although the ridership has marginally increased over the years, which could be due to integration of the intercity Ulster Bus service routes with the Metro Service within Belfast city area. Ulster Bus service connects Belfast with the surrounding town and cities. Contrary to increase in ridership, the average distance travelled by people through Metro Service has decreased. The number of miles travelled per person by Metro Service has decreased from 32 miles per person per year to 28 miles per person per year as shown in Table 1. This could be either due to straightening of routes along main corridors having higher frequency or due to elimination of routes. This paper focuses on the network transmission and examines whether it has benefited the city or vice versa?

Table 1 - Average Distance Travelled by Travel mode: 2003-2005, 2004-2006, 2005-2007 & 2006-2008 – Northern Ireland Travel Survey 2006 – 2008, (Source; DRD, 2009)

Travel Mode	Miles per person per year			
	2003 - 2005	2004 - 2006	2005 - 2007	2006 - 2008
Walk	139	138	144	143
Bicycle	20	18	19	16
Car driver	3,162	3,272	3,247	3,230
Car passenger	1,698	1,669	1,617	1,686
Car undefined	10	2	-	-
Motorcycle	31	30	20	11
Other private	389	448	437	451
City Bus / Metro	32	28	25	28
Ulster bus	261	276	282	270
Other bus	76	66	59	53
NIR	56	72	73	76
Black taxi	6	4	3	3
Taxi	68	69	70	64
Other public	-	-	1	1
undefined mode	1	2	2	1
All modes	5,951	6,094	5,999	6,033

4. METHODOLOGY

Various approaches are identified in the literature which can be used to measure transport related disadvantage. These approaches include accessibility indicator studies, qualitative studies, studies based on exploring the potential of virtual mobility and the activity based modelling approach (SEU, 2003; Hurni, 2005; Church et al., 2003; Currie, 2010). Methodologies have also been developed to assess the impact of transport on the quality of life in an objective fashion, thus providing a platform to examine why, with whom, where and when activities are engaged in, and how activity engagement is related to the spatial and institutional organisation of an area (Kitamura et al., 1997; Carrasco and Miller, 2006). Wu and Hine (2003) utilised GIS to study hypothetical network changes in City Bus network in Belfast city through public transport accessibility levels (PTAL) approach. Four different hypothetical networks were compared in terms of the impact on population structure, car ownership and religious groupings. Analysis indicated that all four hypothetical networks have a disproportionate impact. Social groups experienced varying levels of accessibility during different hours of a day.

Geographical Information System (GIS) has emerged as a key tool for measuring accessibility. GIS has played an important role in two parallel development paths; the spatial perspective and that of transport planning and modelling (Berglund, 2001, Lyborg 2000). Two interdependent spatial categories are applicable to accessibility problems in GIS. These measurable categories are topological accessibility and contiguous accessibility. Topological accessibility refers to measuring accessibility in a system of nodes and paths i.e. a transport network. Contiguous accessibility measures accessibility over a space. It is a measurable

attribute of location, while considering space in a proximate manner (Rodrigue et al., 2006). Network analysis serves as an excellent tool to measure topological accessibility whereas spatial analysis can be used to measure contiguous accessibility. These functionalities of GIS make it one of the most preferable tools for accessibility analysis. For an efficient transport system, it is important that it fulfil the requirements of individuals and communities on both levels (topological and contiguous accessibility).

Using GIS, the paper assesses the impact of network transformation on accessibility levels in Belfast city. It integrates the statistical data for different social groups. Areas, which have improved accessibility, and those, which experienced transport disadvantages within the city, are identified. Figure 1 outlines the methodology adopted.

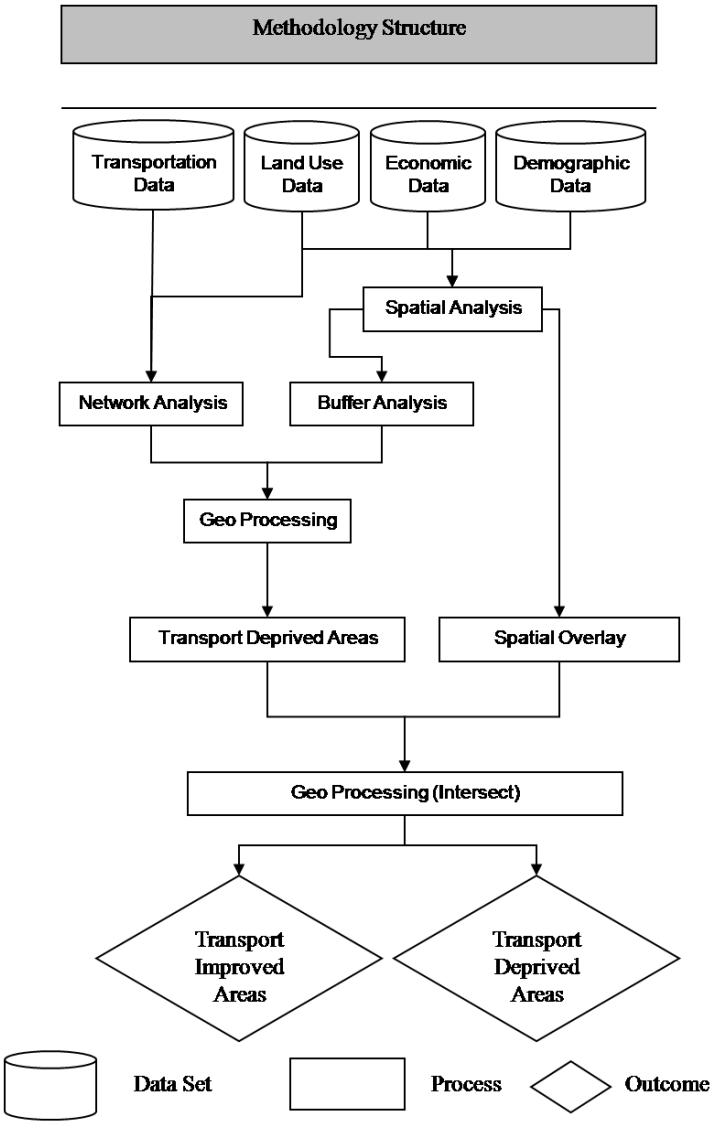

Figure 1 - Methodology Structure

Selection of the spatial unit of analysis is important for describing space and testing of spatial function. Northern Ireland Statistics and Research Agency (NISRA) have defined different

spatial units for census data collection and presentation. These are Output Areas or Enumeration Districts, Super Output Areas, Wards, Local Government Districts and Boards. Output Areas (OA's) are the lowest geographical unit considered in 2001 Census by NISRA. The second lowest geographical unit defined by NISRA are Super Output Areas (SOA's). Output Areas were selected as spatial unit of analysis for the older people, men, women, and young adults' social groups whereas SOA's were used for low-income household as shown in Figure 2 and Figure 3. SOAs were selected for low-income households due to two reasons. Firstly, the poverty data referring economic activity for the household is only available on SOAs geographical level. Secondly, SOAs provided better sample size and transport deprivation depiction for the low-income households.

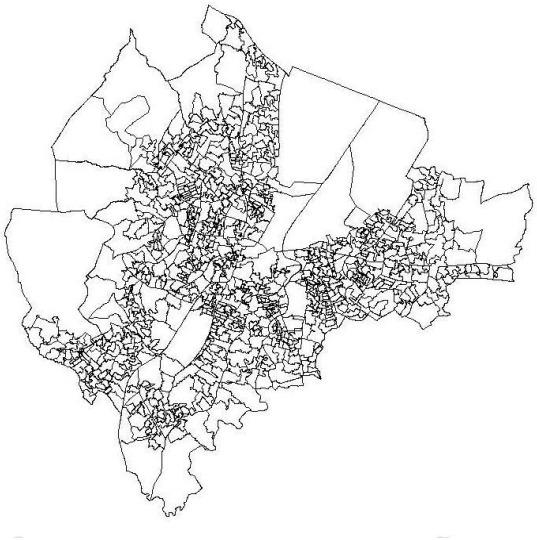

Figure 2 - Output Areas of Belfast

Figure 3 - Super Output Areas of Belfast

Socio-economic data were selected to generate the appropriate indicators from secondary data sources. Table 2 presents the selected indicators for the analysis.

Table 2 - Indicators used for analysis

Social Group	Domain	Indicator
Young Adults	Car Availability (Car Density[1])	Car Density in Output Area*
Elder People		
Women		
Men		
Low Income Household		Car Density in Super Output Area
Young Adults	Demography (Population Density[2])	Population Density age 16 – 25 years
Women		Population Density age 25 - 60 years
Men		Population Density age 25 - 64 years
Elder people		Population Density age 60 – 74 years
Low Income Household		Population Density of Households
Young Adults	Economic Activity (Economic Density[3]) (Pension Claimant Density[4])	Economic Density age 16 - 24 years
Women		Economic Density age 25 - 59 years
Men		Economic Density age 25 - 64 years
Elder people		Pension Claimaint Density age 60 - 74 years
Low Income Household		Percentage of household in Relative Poverty

[1] Car density refers to total number of cars available per unit area
[2] Population Density refers to number of people in a spatial unit of analysis
[3] Economic density refers number of economically active people per unit area
[4] Pension claimant density refers to number of per people claiming pension per unit area

Car density was selected as an indicator because there is a clear difference in license holding between sexes at all age groups although the overall percentage of people holding driving licence in Belfast has remain constant around 70 %. In 2002 – 2004, 59% of young males and 54% of young females aging 17 to 29 years held full driving licences whereas in 2005 – 2007 there number fell down as 34% of young males and 29% of young females held a full driving licence. Although high numbers of individuals hold, a driving licence but they may not have access to car. 52% of the households in Belfast have access to one or more cars (DRD, 2004; DRD, 2007). In addition, Belfast has an aging population. Over the years, the number of pensioners has increased (NISRA, 2009). Translink provides free travel pass to elderly people of age 60 years or above. Elderly people prefer public transport than private means because of free travel pass, health issues etc. Thus, elderly people use public transport but they may hold a driving licence.

Combined data sets, which include statistical data of all social groups, are used in previous studies (Hurni, 2005; NIMDM, 2001, 2005). These combined data sets can influence the results of a particular social group. Therefore, spatial units were attributed with statistical data relevant to each social group, which also aided in measuring relative deprivation among the groups in the city. Densities were calculated through raster calculator. Subsequently, public transport network of City Bus and Metro Service were drawn to develop the public transport system of Belfast city as shown in Figure 4 and Figure 5.

Figure 4 - City Bus Service Network

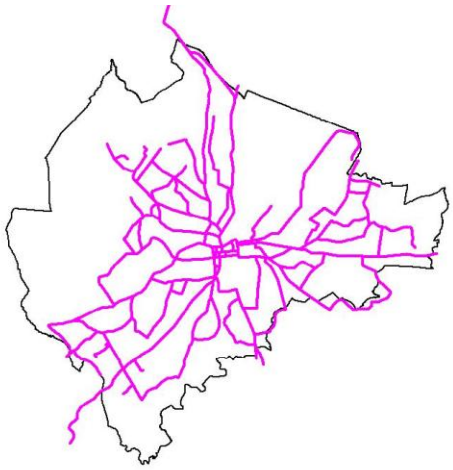

Figure 5 - Metro Service Network

Access zones were defined around the bus stops for both City Bus service and Metro Service using buffer analysis according to the bus stop access distance defined by Department for Transport (DfT) shown in Table 3. Distance of 400 meter was used as bus stop access distance for low-income households, women, men and young adults whereas for older people distance of 150 meter was used as access distance around the bus stop for both the networks. This is because older people cannot walk long distance.

Table 3 - Recommended Distance Limit without a Rest – DfT, (2000a)

Social group	**Recommended distance limit without a rest**
Normal Individuals	400 m
Wheelchair users	150 m
Visually impaired	150 m
Mobility impaired using stick	50 m
Mobility impaired without walking aid	100 m

In the case of Belfast, access zones are important as changes in public transport network affected the provision of bus stop in the city. During transformation of the network, new routes were allocated and old routes were either altered or eliminated. New stops were defined for QBC's and stops on the altered routes were either eliminated or relocated with result of affecting the accessibility of user groups. Therefore, respective stops for both networks were drawn to define access zones. These access zones helped in defining exclusion and inclusion zones. Areas surrounding the public transport network can be sub divided into inclusion zones and exclusion zones considering the access distance to the stop. The inclusion zone is the area around a stop that is reachable and the exclusion zone is the inaccessible area as shown in the Figure 6.

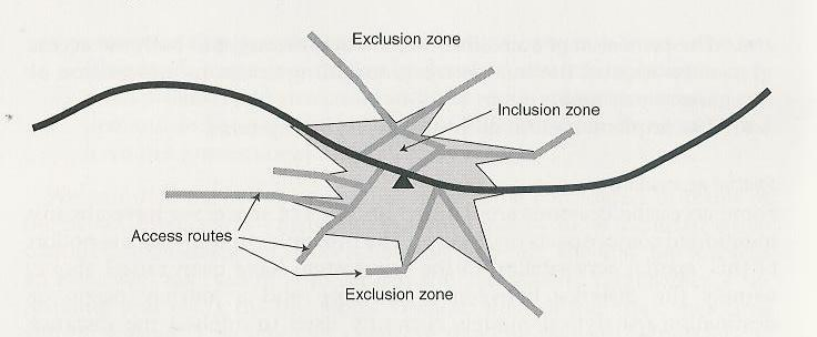

Figure 6 - Inclusion and Exclusion Zone around a Bus Stop – Accessibility and the Bus System (Tyler, 2002)

Service area of public transport system is defined by its frequency, speed and length of road network on which it operates. A public transport system can serve large area but social groups approach the system only through bus stop around their desired activity location. These bus stops serve as exit and entry point. Accessibility offered by a public transport system not only depends on its service area but also on user's ability to reach network through access zones. Buffer analysis usually used to generate buffers around bus stops is not appropriate because it does not consider Euclidian distance. Distance is covered on roads rather in space. In addition, service area refers to composite accessibility (accessibility on a broader scale such as regional level). For individual accessibility (on local neighbourhood level), it is important to examine accessibility offered by the transport system at its entry and exit point. Therefore, this study integrates service area with the bus stop access zone to define actual accessible area of a transport network.

Service areas were generated for each network. Service area polygons were then geo-processed with access zones around bus stops to define actual accessible area for each network. These accessible service areas of both networks were again geo-processed with each other to drive improved and deprived areas due to network change. Accessible service areas for both the networks are shown in Figure 8 and 9.

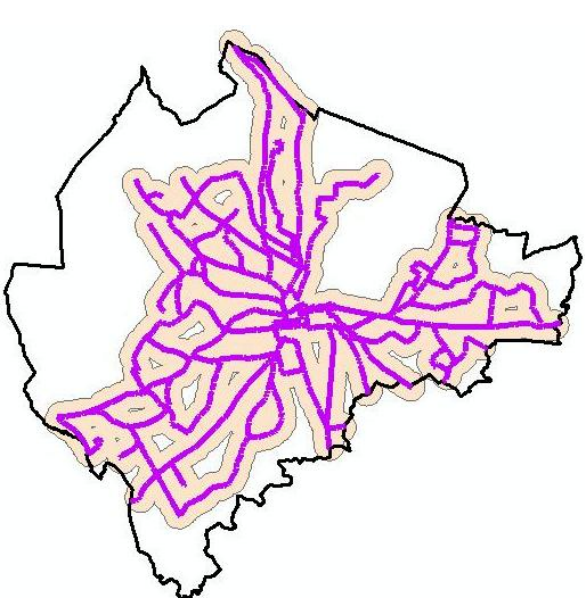

Figure 8 - City Bus Accessible Service Area

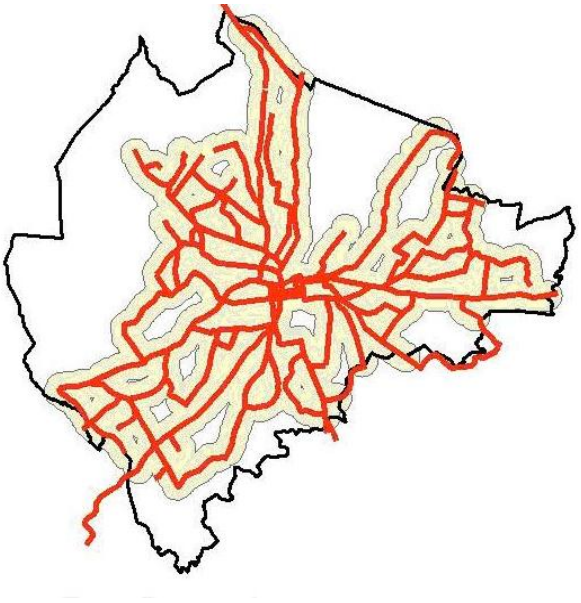

Figure 9 - Metro Service Accessible Service Area

Socio-economic indicators relating to demography, car availability and economic activity for social groups were spatially analysed by assigning weights to the indicators through a common scale of values. Indicator values were classified into five classes having numeric evaluation score from 1 to 5. 1 represented the least value whereas 5 represented the highest value. The class scale values for all the indicators are shown in the Table 4.

Table 4 - Enumeration Scale Values

Enumeration Scale Values			
Social Group	**Data Set**	**Cell Value Range**	**Class Scale Value**
Demography			
Women	Population Density	0- 699	1
Low Incomehouse Hold		700 - 1499	2
Men		1500- 2099	3
Young Adults		2100 - 2700	4
Older People		2800 and above	5
Car Availabilitty			
Women	Car Density	0- 699	5
Low Incomehouse Hold		700 - 1499	4
Men		1500- 2099	3
Young Adults		2100 - 2700	2
Older People		2800 and above	1
Economic Activity			
Women, Men,Young Adults	Economic Density	0- 699	1
		700 - 1499	2
		1500- 2099	3
		2100 - 2700	4
		2800 and above	5
Older People	Pension Claimaint Density	0- 699	1
		700 - 1499	2
		1500- 2099	3
		2100 - 2700	4
		2800 and above	5
Low Incomehouse Hold	Percentage in Poverty	0- 19	1
		20 - 39	2
		40 - 59	3
		60 - 89	4
		90 - 100	5

Employment and access to facilities are equally important to overcome exclusion phenomena. It is also not the areas, which experience deprivation within city. It is the individuals, which experience deprivation as they reside in those areas. Thus, individuals form communities, which experience deprivation so population is as important as employment density and car density. In addition, the underlying research focuses on transport variations in Belfast city not on the socio economic variations of the social group. For socio economic variations of the social groups, weights are important as they become more sensitive. Therefore, equal weights were considered for all data sets. The weighted overlay tool was used to assign weights to each indicator, which resulted in socio economic value for each spatial unit as shown in Figure 7. The impact of weights on the results was tested using sensitivity analysis. All the data sets economic density, population density and

car density had same influence as per their assigned weights. This was because the spatial units, which had high population density, also had high car density and economic density.

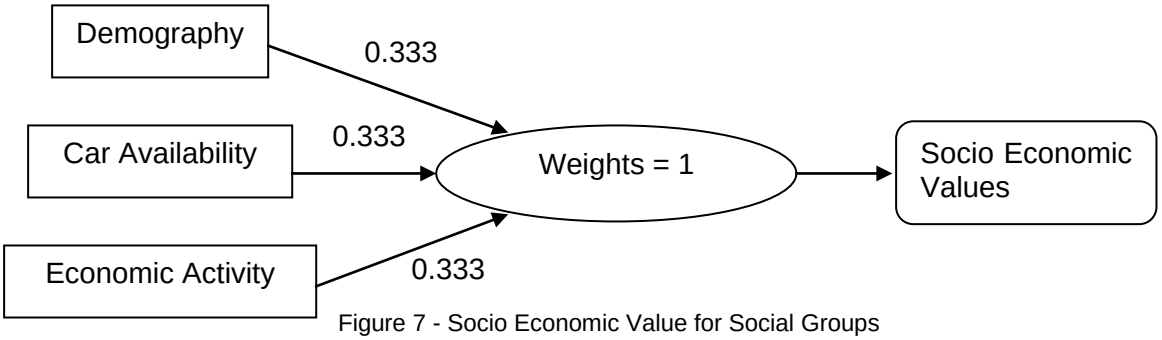

Figure 7 - Socio Economic Value for Social Groups

OA's attributed with socio economic values were then geo-processed with transport improved and deprived areas. Low, medium and high areas on basis of socio-economic values were defined to highlight social group's spatial distribution within the newly emerging patterns of accessibility. Percentage of population experiencing affects of network change was calculated.

5. RESULTS

Metro Service follows the old City Bus network on major roads in the city but within the residential estates, some of the routes are altered and some are eliminated. Old City Bus routes have been eliminated along the Newtownards Road in Knock ward, Whiterock Road, Duncrue Street. Under new Metro Service Springfield Road route is also realigned which has reduced accessibility of areas between Whiterock Road and Springfield Road. OAs along these roads are shown in Figure 10. Table 5 highlight the different areas which have been excluded from Metro Service but were served by the old City Bus with respect to each social group.

The network transformation has improved accessibility of social groups too. Two new routes are defined in Island Ward and Sydenham Ward. This has improved accessibility in output areas along Sydenham Bypass, Annadale Avenue in Rosetta Ward and Upper Springfield Road in Falls Ward shown in Figure 10. Previously these areas were not served by old City Bus service. Table 6 highlights different areas with respect to each social group that have improved accessibility under transformation.

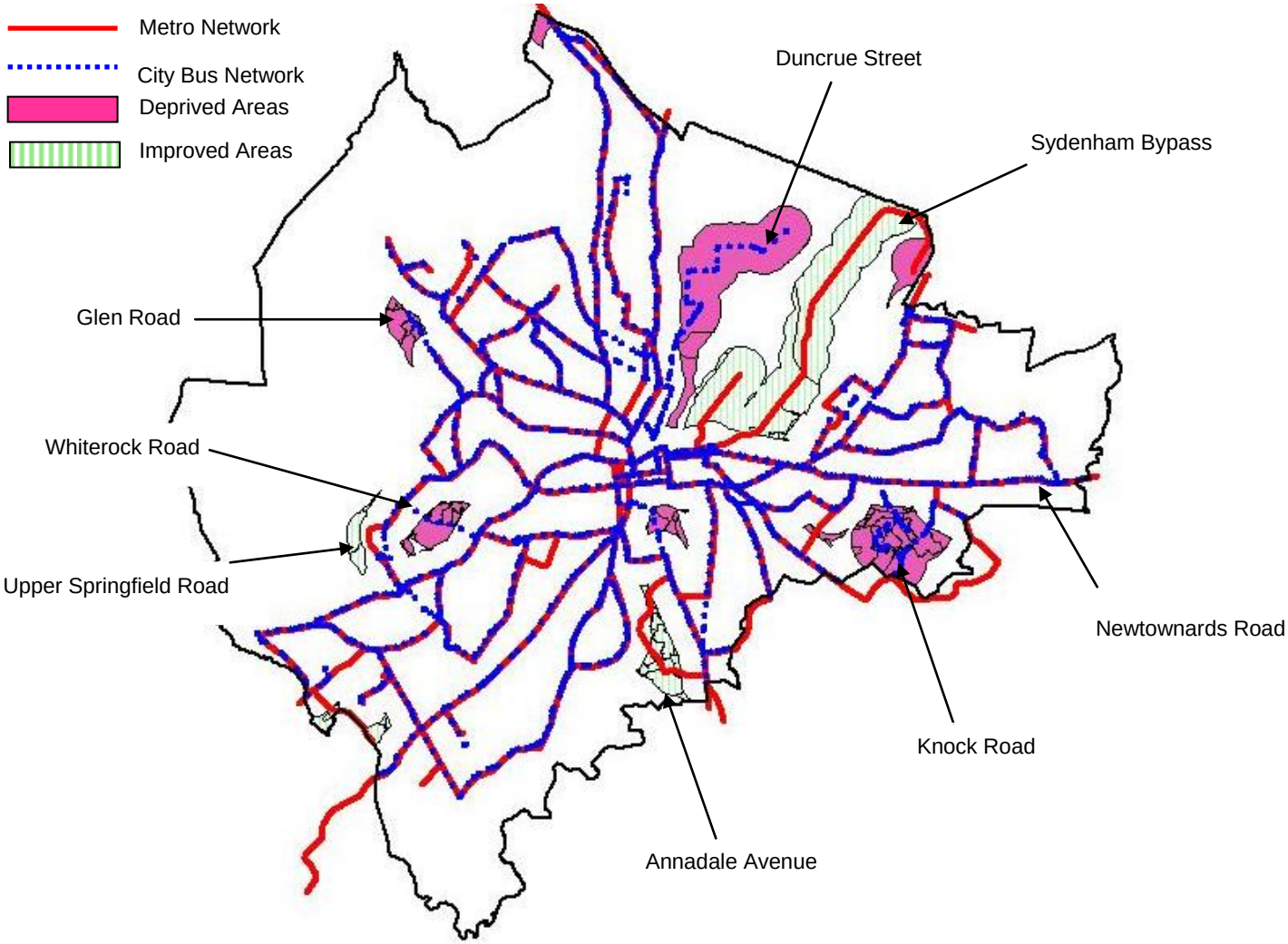

Figure 10 - Transport Deprived Areas due to Network Change

Table 5 – Disadvantage Areas with respect to Social Groups

Social Group	Deprivation Level	OAs / SOAs	Status in Transport Network		Affect on Accessibility Level
			City Bus	Metro Service	
Women	Low	Glencarn. Whiterock, Duncrue	Included	Excluded	Reduced
	Medium	Falls	Included	Excluded	Reduced
	High	Knock	Included	Excluded	Reduced
Men	Low	Glencarn. Falls, Duncrue	Included	Excluded	Reduced
	Medium	Whiterock	Included	Excluded	Reduced
	High	Knock	Included	Excluded	Reduced
Young Adults	Low	Glencarn. Falls, Duncrue	Included	Excluded	Reduced
	Medium	Whiterock, Knock	Included	Excluded	Reduced
	High	Knock	Included	Excluded	Reduced
Elderly People	Low	Glencarn. Falls, Duncrue, Knock	Included	Excluded	Reduced
	Medium	Whiterock, Knock	Included	Excluded	Reduced
Low Income Household	Low	Glencarn. Duncrue, Knock	Included	Excluded	Reduced
	Medium	Falls, Whiterock	Included	Excluded	Reduced
	High	Knock	Included	Excluded	Reduced

Table 6 – Improved Accessibility Areas with respect to Social Groups

Social Group	Inclusion Level	OAs / SOAs	Status in Transport Network		Affect on Accessibility Level
			City Bus	Metro Service	
Women	Low	Sydenham, Island	Excluded	Included	Improved
	Medium	Rosetta	Excluded	Included	Improved
Men	Low	Sydenham, Island	Excluded	Included	Improved
	Medium	Rosetta	Excluded	Included	Improved
	High	Rosetta	Excluded	Included	Improved
Young Adults	Low	Sydenham, Island	Excluded	Included	Improved
	Medium	Rosetta	Excluded	Included	Improved
	High	Rosetta	Excluded	Included	Improved
Elderly People	Low	Sydenham, Island, Rosetta	Excluded	Included	Improved
Low Income Household	Low	Sydenham, Island	Excluded	Included	Improved
	Medium	Rosetta	Excluded	Included	Improved
	High	Rosetta	Excluded	Included	Improved

Identified transport deprived output areas along Whiterock Road, Falls Road, and Duncrue Street are also among underprivileged areas. Northern Ireland Multiple Index of Deprivation (NISRA, 2008) classified output areas in Belfast as underprivileged areas to measure social exclusion levels in the city. The study used a number of domain measures like income, employment, health facilities, education opportunities, skills and training, proximity to services, the living environment, and crime and disorder. This aggregates the isolation of the social groups in these neighbourhoods. Table 7 highlights the rank of deprived areas as per Northern Ireland Multiple Deprivation (NIMDM) study.

Table 7 – Rank of Output Areas as per NIMDM, 2005 – NISRA, 2009

OA / SOA Name	Rank of OA according to NIMDM 2005*
Duncairn	9
Falls Road	24
Falls Park	52
Glen Road	4
Whiterock_2	18
Whiterock_2	40
Whiterock_3	53
Whiterock_3	38

* 1 represents the lowest value and most deprived area

Transport disadvantaged output areas along Knock Road have high ranks. These areas are classified as well-off areas according to NIMDM (2005). Social groups in these areas use either Metro Service or private means of transport. Contrary to option of public hired taxis on Falls Ward, social groups in Knock Ward depend on private means of transport (car or private hired taxi) if Metro Service is not available to them. Women, men, elderly people, young adults and low income households' social groups spatial distribution in transport deprived areas is highlighted in Figure 11, 12, 13, 14, and Figure 15 respectively.

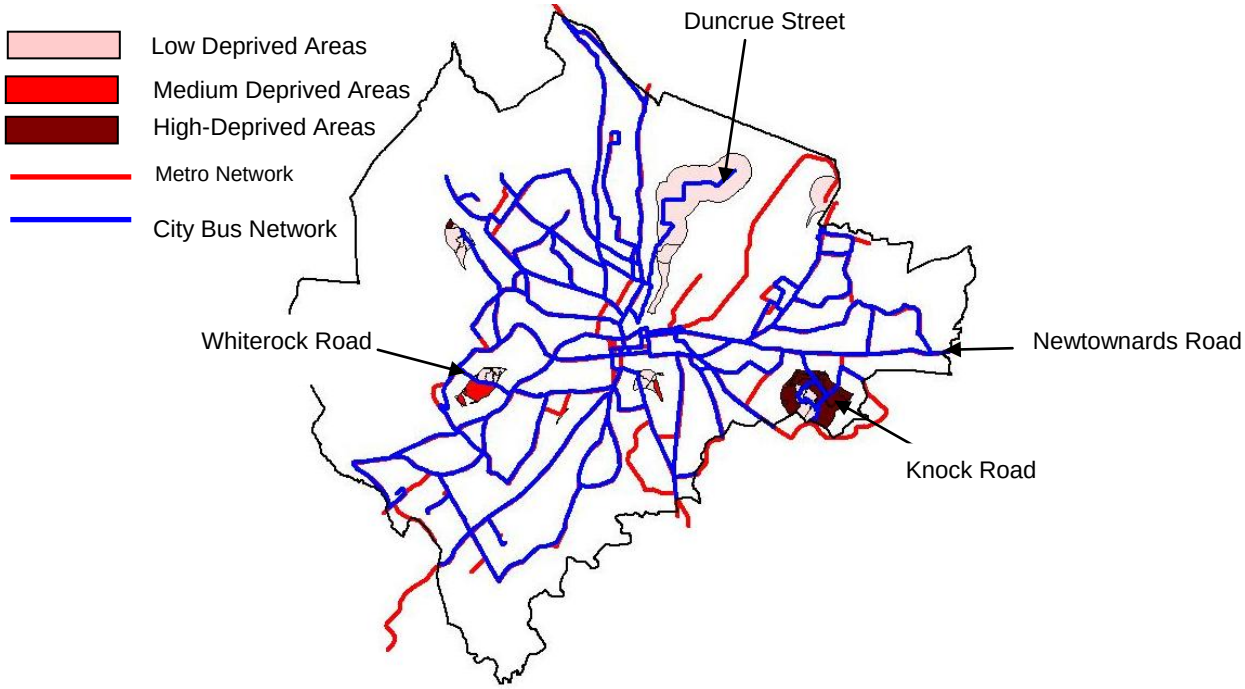

Figure 11 - Spatial distribution of Women in Transport Deprived Areas

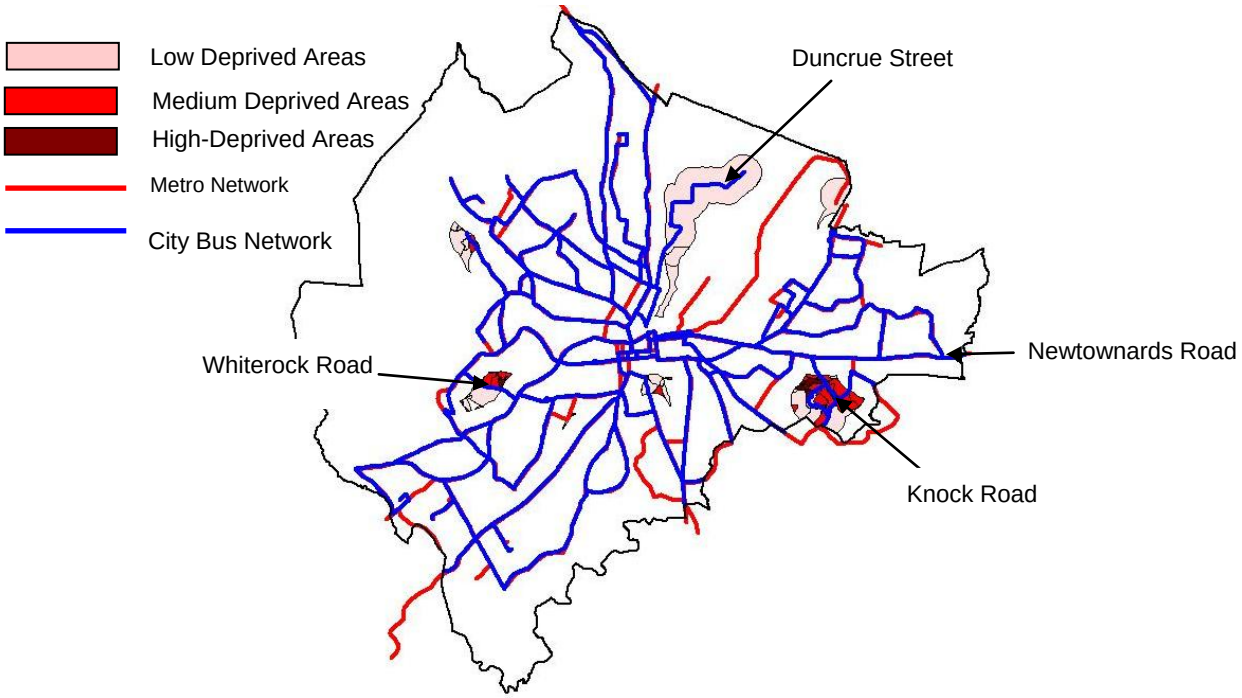

Figure 12 - Spatial distribution of Men in Transport Deprived Areas

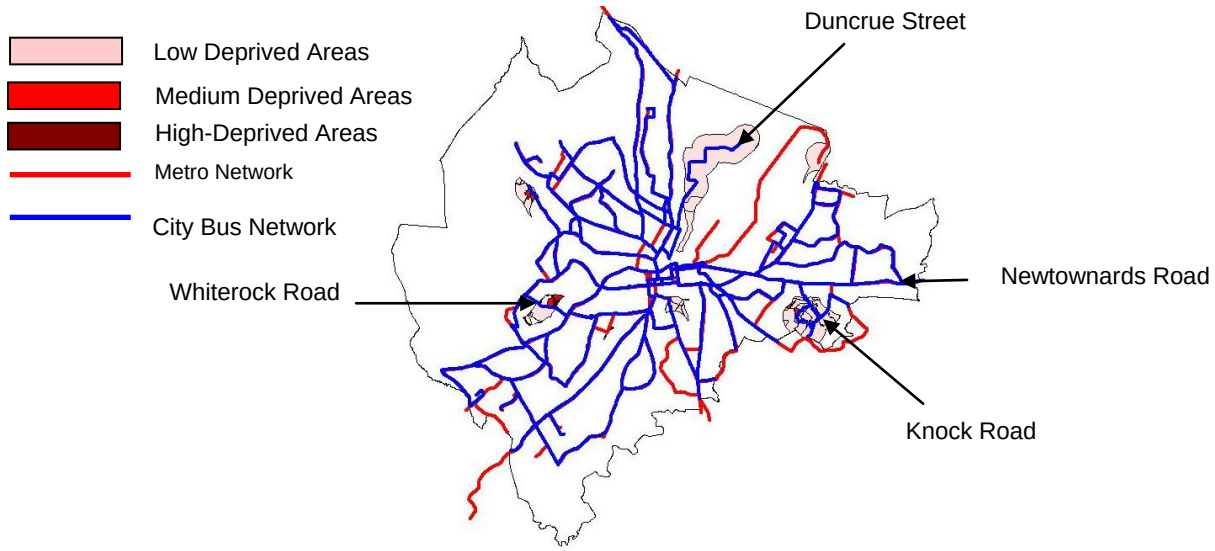

Figure 13 - Spatial distribution of Elderly People in Transport Deprived Areas

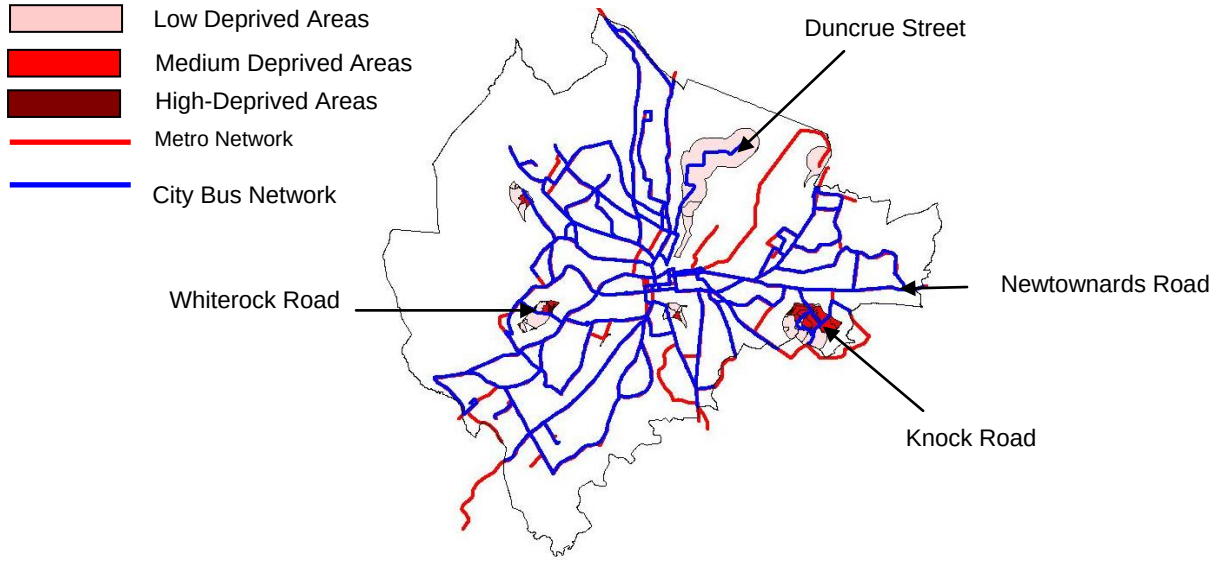

Figure 14 - Spatial distribution of Young adults in Transport Deprived Areas

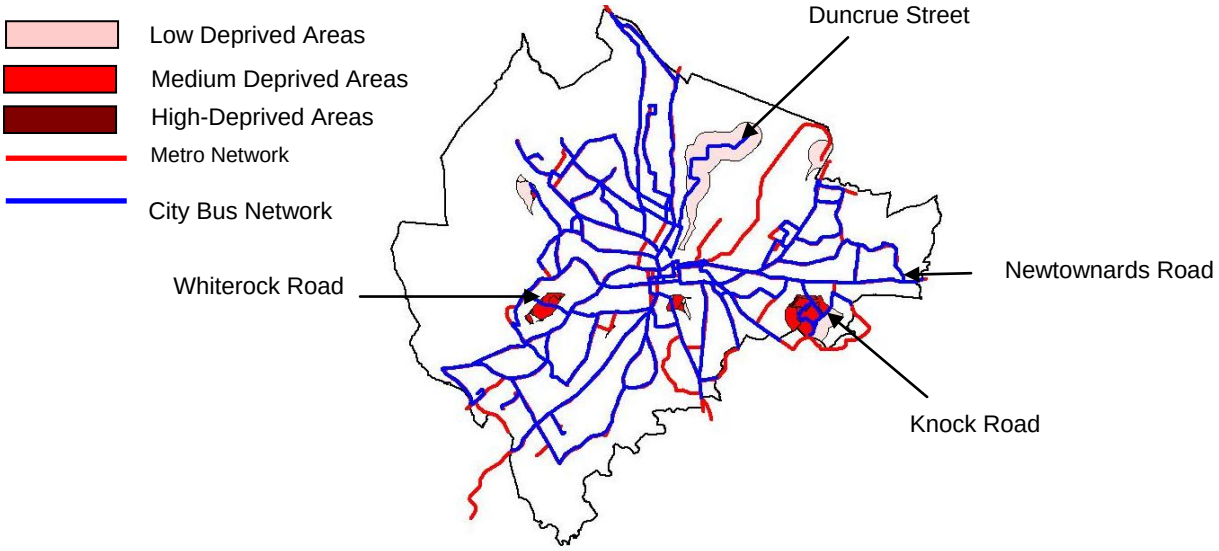

Figure 15 - Spatial distribution of Low Income Households in Transport Deprived Areas

Figures 11 - 15 reveal that social groups are spatially scattered in the transport-deprived areas. In the Knock Ward along the Newtownards Road, all social groups except older people have experienced exclusion due to network transformation. Women and low-income households on the Whiterock Field Road in the Whiterock Ward have also experienced disadvantages compared to other groups in the area due to network change.

Network transformation has also reduced accessibility to Duncrue street industrial area in the north of city. Being an employment hub, the area provides jobs and serves as a transit junction for freight delivery in the whole region. Table 8 highlights the percentage of population experiencing transport disadvantages according to each social group in OAs and SOAs. Low medium and high-deprived areas were classified based on socioeconomic values within GIS. Low deprived areas refers to those areas where accessibility levels are least affected by transport network transformation. The Most deprived areas include total population of social groups in the neighbourhood areas that indicates that certain social groups have experience deprivation more as compared to other groups in the OA neighbourhoods.

Table 8 - Percentage of Population Experiencing Transport Disadvantages as per Social Group

Social Group	Spatial Unit of Analysis	Deprivation Level	Total Population [No. of Individuals]	Number of People Excluded From Network [No. of Individuals]	Percentage of Population experiencing Transport Disadvantgaes [%]
Women	Output Area	Less	54	15	28
		Medium	81	45	56
		Most	80	80	100
Men	Output Area	Less	35	3	9
		Medium	80	57	71
		Most	100	100	100
Young Adults	Output Area	Less	54	12	22
		Medium	16	10	63
		Most	60	58	97
Older People	Output Area	Less	27	5	19
		Medium	62	32	52
		Most	66	60	91
Low Income household	Super Output Area	Less	739	237	32
		Medium	650	432	66
		Most	1018	509	50

* Total population of each social group in spatial unit was obtained from NISRA Census Data
** Number of people excluded from network was calculated through area of disadvantaged OA and the population density in that OA
*** Percentage of population experiencing transport disadvantages was calculated through total population and population experiencing disadvantage

Elderly people, women, young adults, men, and low income households' social groups spatial distribution in improved accessibility areas is highlighted in Figure 16, 17, 18, 19, and Figure 20 respectively.

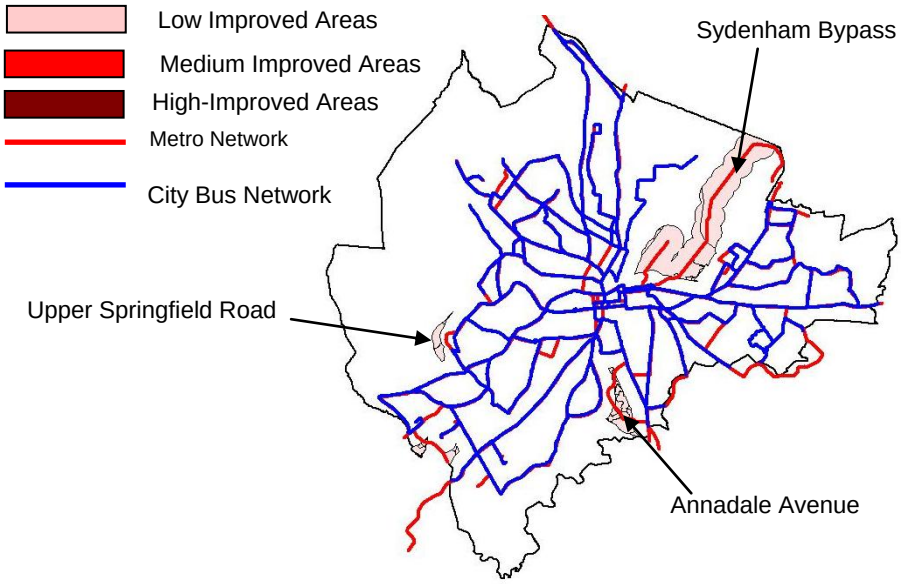

Figure 16 - Spatial distribution of Elderly People in Improved Accessibility Areas

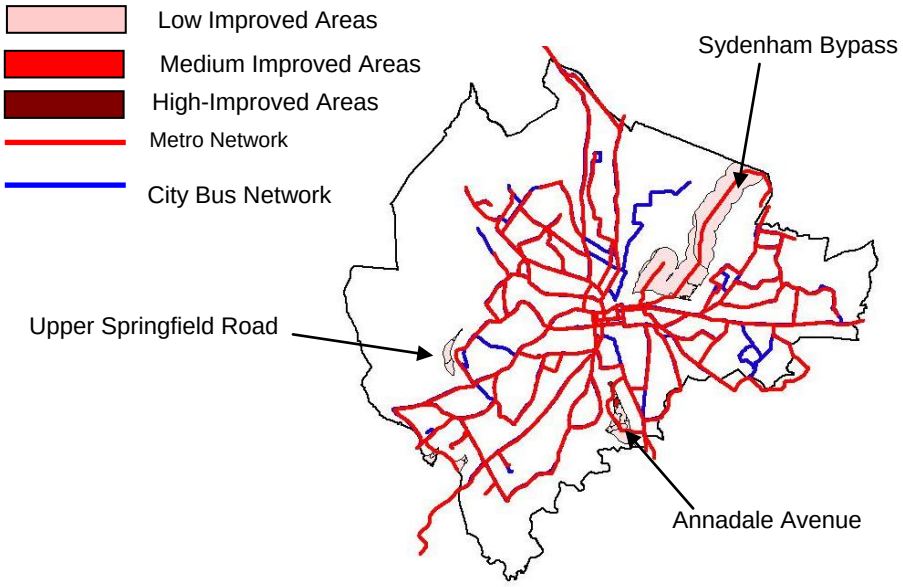

Figure 17 - Spatial distribution of Women in Improved Accessibility Areas

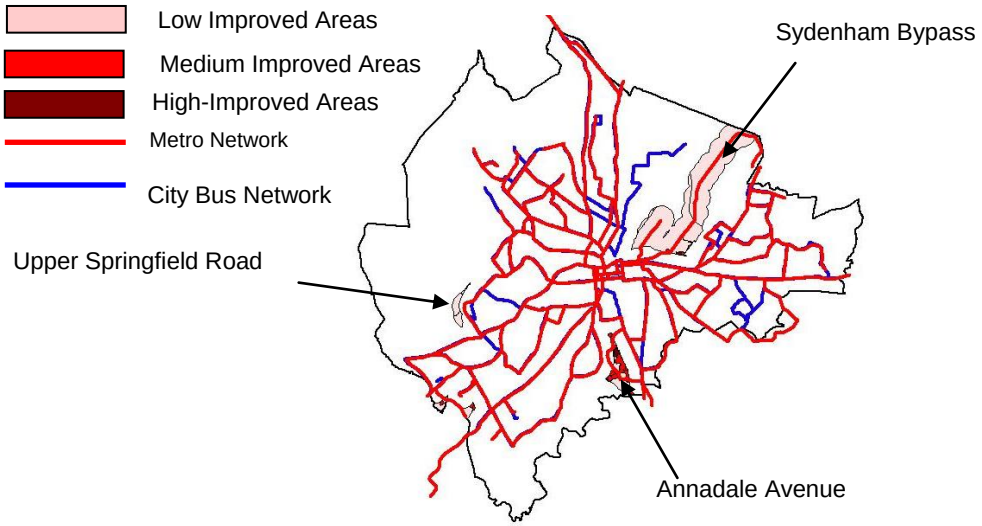

Figure 18 - Spatial distribution of Young Adults in Improved Accessibility Areas

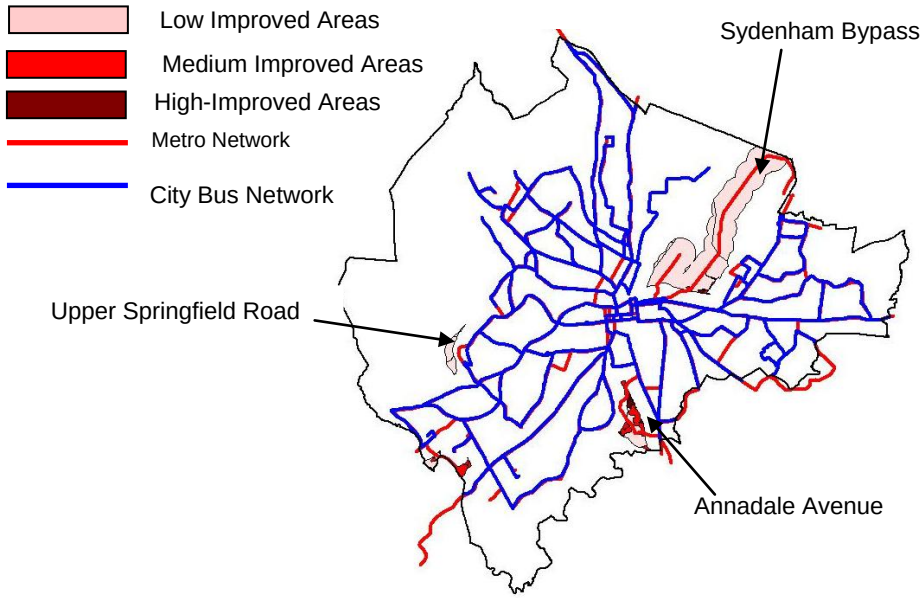

Figure 19 - Spatial distribution of Men in Improved Accessibility Areas

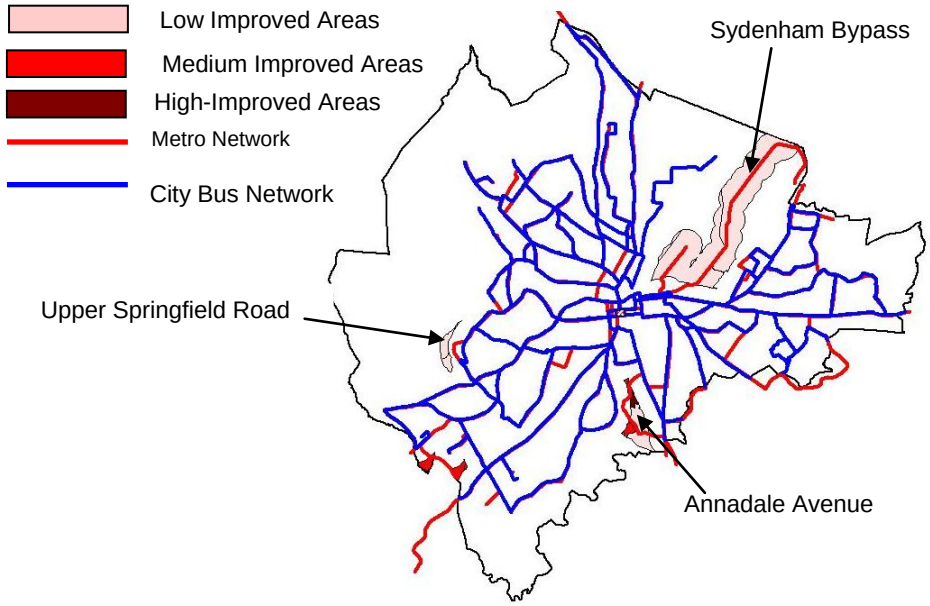

Figure 20 - Spatial distribution of Low Income Households in Improved Accessibility Areas

Figures 16 - 20 reveal that improved areas were not served previously by City Bus service. Their inclusion within new Metro Service system has improved accessibility of various social groups in these areas. Table 9 highlights the percentage of population experiencing improved accessibility according to each social group in spatial units of analysis. High-improved areas are those areas where new routes or realignment of old City Bus routes has improved accessibility of social groups. Some social groups are more advantageous comparatively to others groups in these output areas, which refers to the fact that advantages due to network change are relative among social group. This raises the need of further qualitative study that should examine the transport needs of different social groups.

Social groups except older people in Ballynafeigh Ward along Annadale Avenue are benefited by network change as they experience improved accessibility. The network

transformation has not affected older people's social group much as they are spatially distributed around city centre area. City centre area being the origin and destination of all trips is least affected from network change. Old people prefer walking and easy access to their local activity spaces therefore they prefer to live near or in city centre areas.

Table 9 - Percentage of Population Experiencing Improved Accessibility as per Social Group

Social Group	Spatial Unit of Analysis	Inclusion Level	Total Population [No. of Individuals]	Number of People Included in Network [No. of Individuals]	Percentage of Population having improved accessibility [%]
Women	Output Area	Low	62	18	29
		Medium	68	33	49
		High	72	66	92
Men	Output Area	Low	64	25	39
		Medium	66	48	73
		High	72	68	94
Young Adults	Output Area	Low	47	15	32
		Medium	39	22	56
		High	32	28	88
Older People	Output Area	Low	80	20	25
		Medium	62	43	69
		High	68	59	87
Low Income household	Super Output Area	Low	734	150	20
		Medium	873	400	46
		High	917	775	85

* Total population of each social group in spatial unit was obtained from NISRA Census Data

** Number of people included within network was calculated through area of improved OA and the population density in that OA

*** Percentage of population experiencing improved accessibility was calculated through total population and population experiencing improvement

In some areas of Belfast city, stage carriage known as public hired taxis or Black Taxis also exists. Political and sectarian conditions, which prevailed in the city, had led to its development (O'Hearn and Tomlinson, 2001). Transport disadvantages due to network change have further promoted social groups in the Falls Ward, Springfield Ward and Whiterock Ward to rely on this alternative means of transport. Currently Belfast city has more than 300 private taxi companies in the city along with a well-established network of public taxis on the Falls Road, Springfield Road and Whiterock Road. These public taxis operate along the Metro service on corridors and links the neighbourhoods (see Figure 16). The research study by Time Associates on behalf of West Belfast Taxi Association (WBTA) has revealed that people make more journeys through shared taxis than bus in the west of city where a strong network of shared taxis is present. Out of 3508 journeys recorded during the survey in west of Belfast more than 3231 journeys were made by Black Taxis. Average number of journeys per week per person by Black Taxis approximates to 7.7 and for bus the same was equal to 0.5 (WBTA, 2009). Their frequency is also higher than bus service in peak hours and passengers ride from their neighbourhoods. Around 50% of people who use Black Taxis prefer them because they are next available mode of transport. Black Taxis also serve area along Upper Springfield Road, which was not served by old City Bus. This indicates that during times of trouble when bus service was often removed, taxis serve as lifeline for groups in these areas.

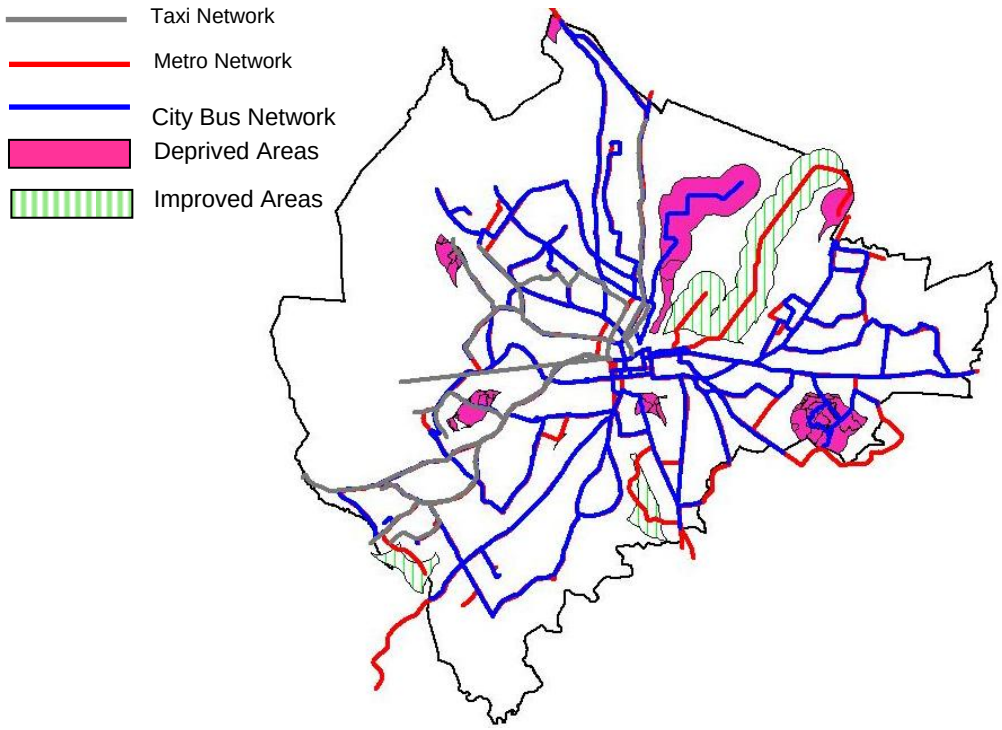

Figure 16 - Taxi Routes in Transport Deprived Areas

After the transformation, walking has also emerged as an important alternate mode of transport other then private cars and public taxis. The number of people who prefer to walk has risen from 16 % to 25 % (DRD, 2009). Deprivation of areas due to transport network change can be one of the reasons for this change. This should be examined through future assessments so that reasons for the change can be established and those areas where walking has emerged as alternate mode of transport, should be provided with adequate infrastructure.

So far, the aims of the transformation have not been achieved in real spirit. Network change and new QBCs has further augmented the prevailing exclusion patterns in the city. Network transformation has resulted in further deprivation of those areas, which are also classified as underprivileged areas by NIMDM 2005 (NISRA, 2009). Transport can serve as an important tool for redevelopment of these deprived areas. To achieve the planned aims of transformation and to enhance the efficiency of the Metro service, it is important to carry out a composite accessibility assessment. The assessment should investigate both objective and subjective nature of transport disadvantages due to network change. Objective nature of the assessment will help in establishing the number of people that have experienced disadvantages whereas subjective nature will help in addressing the transport needs of social groups. The methodology adopted in the paper to identify areas can be considered to address the objective nature of transport disadvantages whereas qualitative assessment in the deprived areas can help in studying the impacts of transport deprivation in social group's life. Policy makers can follow the methodology to examine the impacts of network change but due considerations should be made to socio-economic variables as different regions have different socio-economic variables.

6. CONCLUSION

Societies are characterised by interactions among different social groups through a layers of spatially dispersed networks. Transport is one of these prevailing networks in the society connecting people with the locations. The configuration of the transport network within society affects the levels of accessibility offered by the system itself. This is due to the reason that transport manipulates pattern of exclusion experienced by social groups. The spatial impact of the network changes is clearly shown by mapping the City Bus network and Metro Service network in Belfast. The network change and creation of high frequency corridors in Belfast city has dual affect on social groups. In some areas of city, it benefited social groups whereas in other parts it reduced their accessibility. The network transformation has also promoted the prevailing exclusion patterns in the city. This is because the areas on west side of the city, which have experienced disadvantages, are also among the most underprivileged areas as measured by NIMDM – 2005 (NISRA, 2005). The deprived areas on the east side although are not among underprivileged areas but have no other means of public transport to rely on. Social groups either depend on private cars or hire taxis in these areas. This may enforce them to make tradeoffs among their amenities of life thus leading them to social exclusion from their desired activities.

Although there has been a marginal increase in the number of people, who are able to get a bus from their nearest bus stops but so far, better access to facilities is not fully achieved. The affects of network change is relative among social groups. Social groups other than older people in OAs of Knock Ward along Newtownards Road are among the high-deprived areas due to elimination of the routes in their neighbourhoods. Women's social group living along the Whiterock Road in Whiterock Ward and Falls Ward are the most disadvantaged group. Men, women and young adults are benefited due to network change in Ballynafeigh area as they have better access to transport.

Social groups within deprived areas also rely on other modes of transport to access their activity spaces. To enhance the ridership of public transport network and to shift the trend from private transport to public transport in the Belfast city, it is important to define a robust policy framework focused towards accessible public transport delivery. A comprehensive qualitative accessibility assessment is required, which should address transport needs of social group by examining the transport disadvantage inflicted by the network change. Based on the results of this paper, qualitative research in progress will help in addressing the research issue of public transport network change and social exclusion in Belfast City.

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