THE CHANGING SOCIO-ECONOMIC STRUCTURE OF DALLAS, US

THE NEW LIGHT RAIL TRANSIT LINES AND RELATED LAND USE CHANGE

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This paper explores a new phase of urban development based on a case study of Dallas, Texas. The key feature of the North American metropolitan areas is the relatively weak CBD core. Many issues related to social problems, for example increasing number of immigrant shares or more non-English speaking people, often push the major urban functions out toward the suburbs and many high-density office complexes are found separate and far from the CBD as a result. In this paper, the authors examine the new efforts by city councils and other related organizations to reorganize suburbanized functions around a new public transportation system, the light rail transit (LRT). After the completion of the LRT in 1996, a new pattern of commuter flows and an increased urban development close to the newly opened stations occurred.

INTRODUCTION

In America each of the top 20 major metropolitan areas has undergone a population increase, and in 14 of the 20 areas, this increase has exceeded 10% during the 1990 – 2000 census periods. It is a characteristic of American metropolitan areas that the total extent of a built-up area grows with that rapid population increase.

In general, the changing American metropolitan structure has been characterized by the suburbanization of residences and offices for middle to upper class people. Suburban downtowns, which include high-rise office complexes in the suburban cores, had been very common until the early 1990s. Since the mid 1990s, a dispersion of low density offices has been growing in the peripheral areas creating the so-called "edgeless city" which is the typical place of work for white middle to upper class people. While a greater number of white middle to upper class people prefer to disperse to the suburbs, minority groups, mostly low income residents, tend to remain within the central city. According to Narita (2005), this can be described as an expansion of social segregation within the entire metropolitan area, which used to be apparent in the smaller intra-urban levels.

McLafferty and Preston (1991) noted that some minority groups remaining within the city center suffered from problems of longer-time and distance when commuting due to the decreasing amount of employment within the downtown areas. This also created a higher rate of commuters who used their own cars for work rather than public transportation. Improving public transport system connections between the CBD and the growing suburbs had been one of the most important problems in the major metropolitan areas. The growing suburbs cannot be sustained solely by middle to upper class residents. Suburban offices for middle to upper class people require many related services, such as cleaning, building maintenance etc., which are usually supported by low-income blue-collar workers. These workers have recently tended to move close to the suburban cores in order to get better paid jobs. Many examples of new and innovative public transport systems can be found in major metropolitan areas, having been introduced solely to solve this kind of spatial polarization problem. The new systems are expected to connect the CBD to the ever expanding suburbs. In addition, the introduction of new public transportation is also important in giving workers the opportunity to commute without their own cars, which is also important from the point of environmental concerns.

In the 1970s and early 1980s, in relation to the sudden rise in oil prices, there were strong arguments for and against some state government's policies aimed at controlling or managing state growth. In those days social infrastructures had already been improved in the suburbs and resulted in the previously mentioned spatial polarization problems: middle to upper class people preferring the suburbs; minority or low income groups staying within the 'empty downtowns'. Job-housing imbalances, spatial mismatches and urban sprawl had been major concerns for city planners (Cervero and Taniguchi 2004), and a smart growth policy became an attractive alternative; a comprehensive city plan which might focus on improvements in the quality of life, the conservation of the natural environment and the correction of social imbalances. Although many local governments adopted smart growth policies, actual measures in the early days of their inception were limited: less use of private cars, car sharing among several persons and the adoption of the HOV (high occupancy vehicle) lanes on the major road networks were common policies which led to a reduction in energy consumption.

Corresponding to the need for such policies, new efforts by local governments and other related organizations have been made in many major metropolitan areas in the last decade, for example, the introduction of new public transport systems such as the LRT (Light Rail Transit). In addition some residential redevelopment projects have been conducted in the CBD as it has become common for some middle to upper class people to return to inner city living; and good accessibility to better paid jobs was given to low income groups thanks to the improvement of social infrastructures. These efforts are significant in terms of a compact/ high density development within the city. Revitalization in the city center and relocation of residences toward the suburbs by lower income people have created a so-called 'social mix', which should be highly valued. Some local governments were satisfied with the effects of the policy; however some researchers claimed that it was not efficient in improving the employment opportunities for low income groups (Sanchez et al. 2004).

Given this general observation, this paper addresses the following objectives: to estimate how greatly the introduction of a new LRT has changed socio-economic characteristics within the Dallas metropolitan area; to focus on the changes of land use and commuter flow citing the cases of two sample stations along the new LRT lines; and to question whether the smart growth project has been effective in changing metropolitan structures as well as environmental viewpoints.

The U.S. Census data for 1990 and 2000 were primarily used in this article. In addition, the OD data (origin and destination data, based on the place of employment) of the Census Transportation Planning Package (CTPP) compiled by the Bureau of transportation statistics (BTS) and land use maps drawn by the North central Texas councils of governments (NCTCOG) were also obtained. A GIS package was used to assist in representing, processing and visualizing spatial data.

SOCIO-ECONOMIC STRUCTURE OF THE DALLAS METROPOLITAN AREA

The Dallas PMSA, combined with the Fort Worth PMSA, forms the Dallas-Fort Worth CMSA, the US 9th biggest metropolitan area (Figure 1). The whole area of NCTCOG covers the two major cities (Dallas and Fort Worth) and the surrounding sixteen counties. The metropolitan planning area, as a heart area of the total CMSA, includes two major counties (Dallas and Tarrant counties) and the full extent of Denton and Collin counties in the north, Rockwall county to the east and parts of Kaufman, Ellis and Johnson counties to the south, and Parker county to the west.

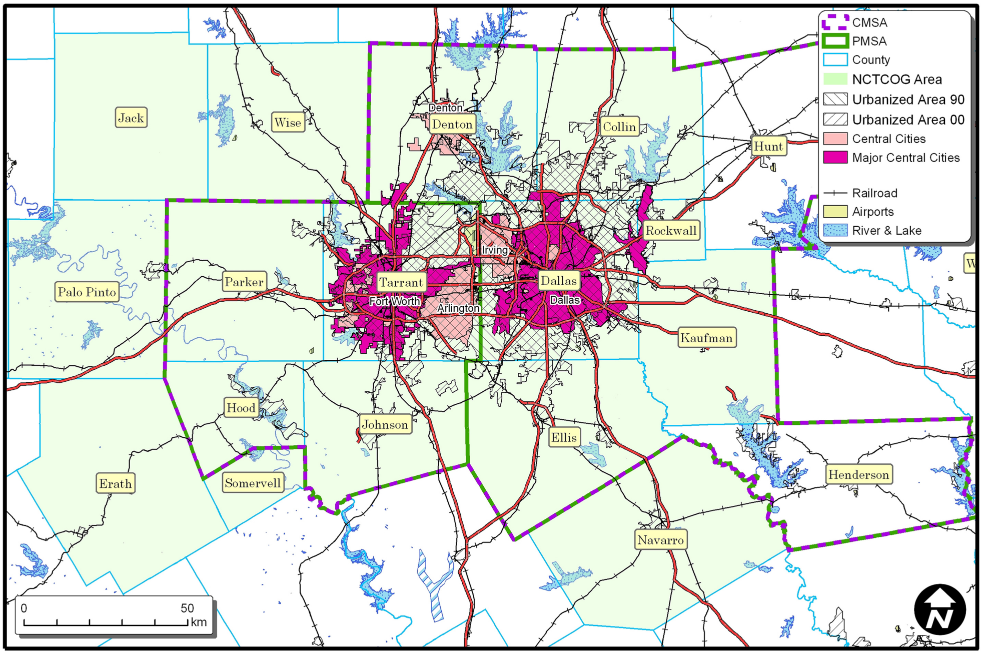

Figure 1 Dallas and surrounding area
PMSA: Primary Metropolitan Statistical Areas.
CMSA: Consolidated Metropolitan Statistical Areas.
Source: US Census Bureau

The population of the Dallas PMSA is 3.5 million, about two-thirds of the total CMSA (Table 1). As with other US metropolitan areas, the Dallas PMSA has experienced multi- nucleation since 1980s. The population of the area of NCTCOG has dramatically increased and is expected to increase from 5.1 million persons in 2000 to nearly 9.1 million in 2030. Employment is also expected to increase from 3.2 million in 2000 to nearly 5.4 million in 2030 (NCTCOG 2003).

	Population (X1,000)			Net increase (X1,000)	Increasing rate (%)	Area
	2000	1990	1980	2000-1990	2000/1990	sq mile
Dallas – Fort Worth CMSA	5,222	4,037	3,046	1,185	29.3	9,097
Dallas PMSA	3,519	2,676	2,055	843	31.5	6,185
Dallas City	1,189	1,007	905	182	18.0	343
Fort Worth City	535	448	385	87	19.5	293
Atlanta MSA	4,112	2,960	2,233	1,152	38.9	6,119
Atlanta City	416	394	425	22	5.7	132

Table 1 Difference between Dallas – Fort Worth CMSA and Atlanta MSA
Source: US Census Bureau

There have been a large number of studies of multi-nucleation process in metropolitan areas. Wheeler (1986) discussed the characteristics of suburban location of headquarter offices in the Atlanta metropolitan area. Hartshorn and Muller (1989) provided a clear definition of the term 'suburban center'. And Fujii and Hartshorn (1995) elaborated on the multi-nucleation process and related features of the changing metropolitan structure of Atlanta. The Dallas and Atlanta metropolitan areas are almost the same in terms of population size; therefore the literature on Atlanta is very informative for understanding Dallas. As for Dallas, Jenkens (1996) analyzed a long-term trend of office location (1950–1990) using some statistics on employment. Also in Garreau (1991) and Lang (2003), the multi nucleation process in Dallas was featured as one example in the study of suburban center in US metropolitan areas. However, despite of these notable studies, there are some problems for arguing that the characteristics of the Dallas metropolitan area are similar due to Dallas's relatively larger central city compared to Atlanta[1]. For example, the area of the city of Dallas is so huge that it includes not only the CBD but also several suburban downtowns within its area. For this reason, some previous studies, for example Katz and Lang (2003) and Narita (2005) had to offer a special definition for the extent of the Dallas central city when they analyzed the social differences between the central city and suburbs during the 1990 – 2000 census periods.

Ishikawa (2005) examined the relationship between building locations and socio-economic structure in the Dallas PMSA using social statistics based on census tracts, economic statistics, and office location data. In this article the authors provide a general overview of the social structure of the Dallas metropolitan area using OD data from the Census Transportation Planning Package (CTPP) 1990 and CTPP 2000 transportation datasets based on traffic analysis zone (TAZ) level data.

Figure 2 shows the population change and Figure 3 employment changes in the major parts of the Dallas PMSA, 1990-2000 based on TAZ level data. Suburban areas, covering 30km radius zone, offer a clear contrast with the CBD in terms of both population and employment. In addition, the higher rates of population and employment increase occur predominantly in the outer suburbs (e.g., 30 km radius zone), especially in the north-west suburbs. Some of them can be identified as edgeless cities.

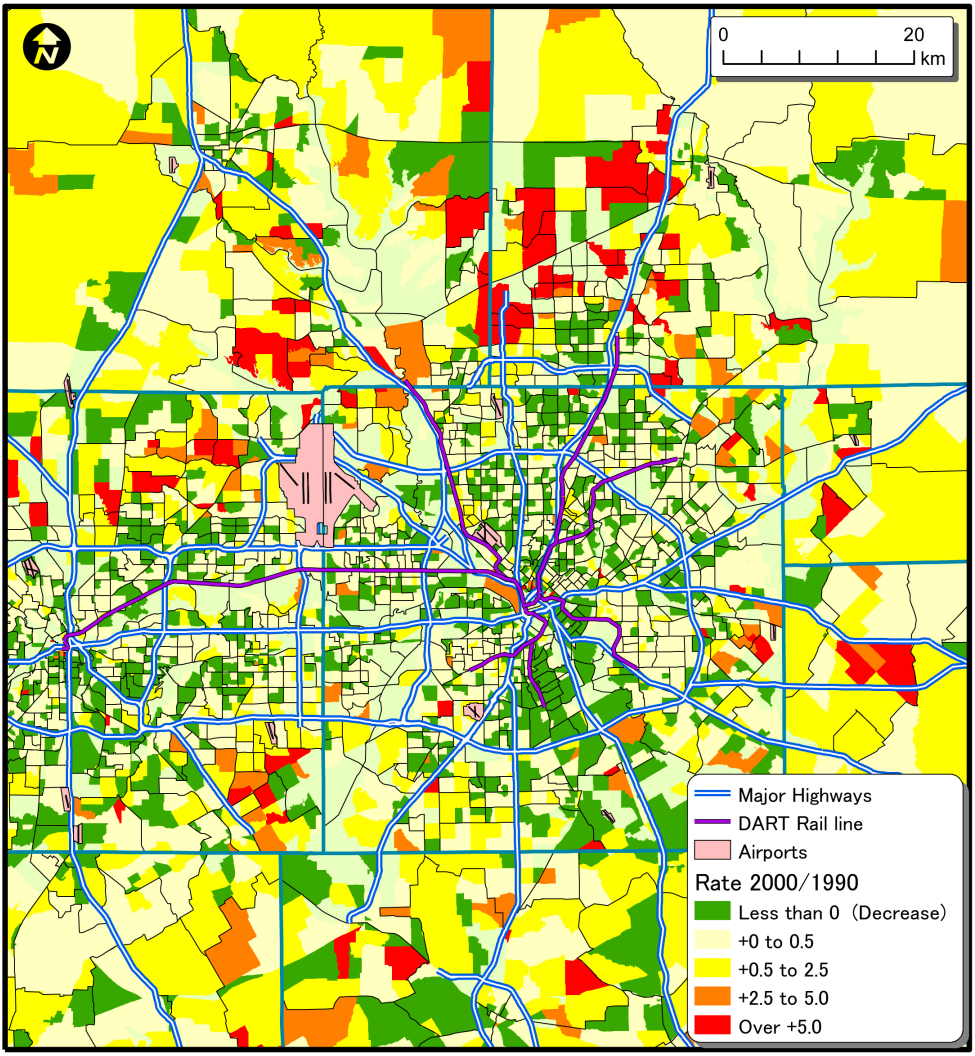

Figure 2 Population change in Dallas area (1990–2000)
Based on TAZ spatial unit
Source: CTPP1990 and CTPP2000

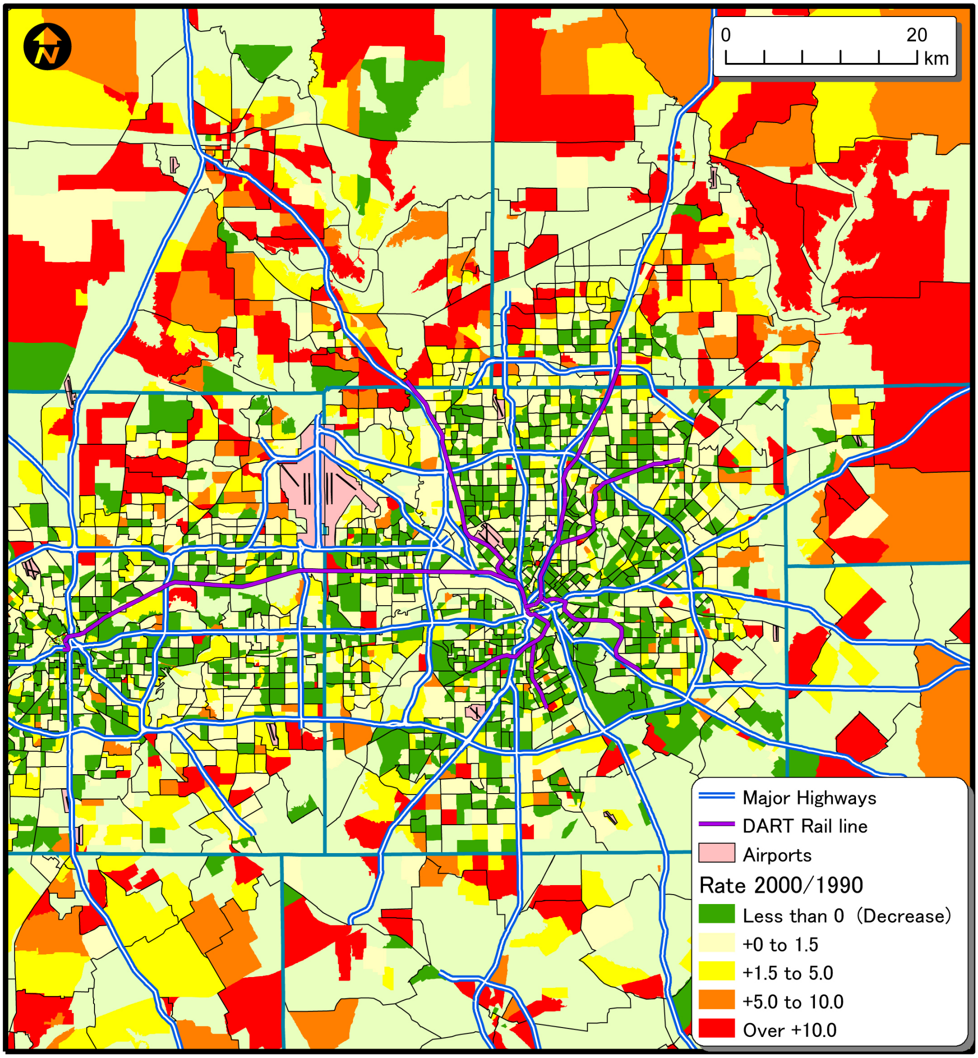

Figure 3 Employment change in Dallas area (1990–2000)
Based on TAZ spatial unit
Source: CTPP1990 and CTPP2000

Compared to other major US metropolitan areas, the Dallas metropolitan area shows a relatively higher rate of Hispanic population as well as lower rate of Asian people. The largest racial-ethnic group in the Dallas metropolitan area is White (67.2%), followed by Hispanic (23.1%), Black (15.1%), and Asian (4.0%). The major racial-ethnic group in the Dallas central city is White (50.9%), followed by Hispanic (35.6%), Black (25.8%), and Asian (2.7%). In addition, the size of minority groups in relation to the total population in the Dallas metropolitan area is relatively small. This is because of the larger extent of the city area and the concentration of high income groups living within the central city. This high income concentration occurs in a corridor/sector extending from the CBD to northern suburbs (Figure 4). In contrast, southern suburbs of

Dallas metropolitan area have higher proportions of low income people. Figure 5 and Figure 6 show the distribution of major racial groups in the Dallas area in 1990 and 2000. Generally, the Hispanic group has increased both in the central and suburban areas during the period. The high rate of increase of the White group occurs predominantly in the northern outer suburbs, while other minority groups have increased markedly along the newly extended LRT corridor (DART).

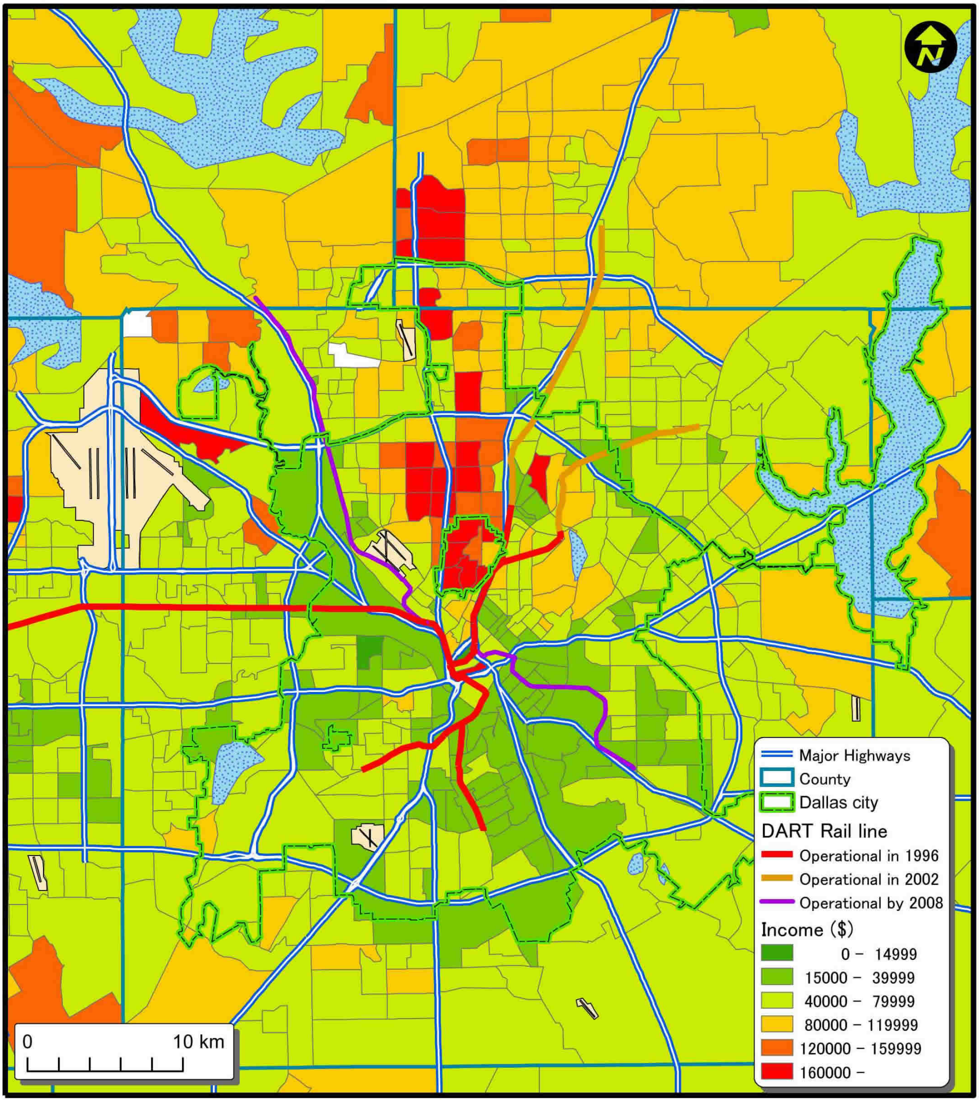

Figure 4 Distribution of household income (1999)
Based on census tract
Source: US Census 2000

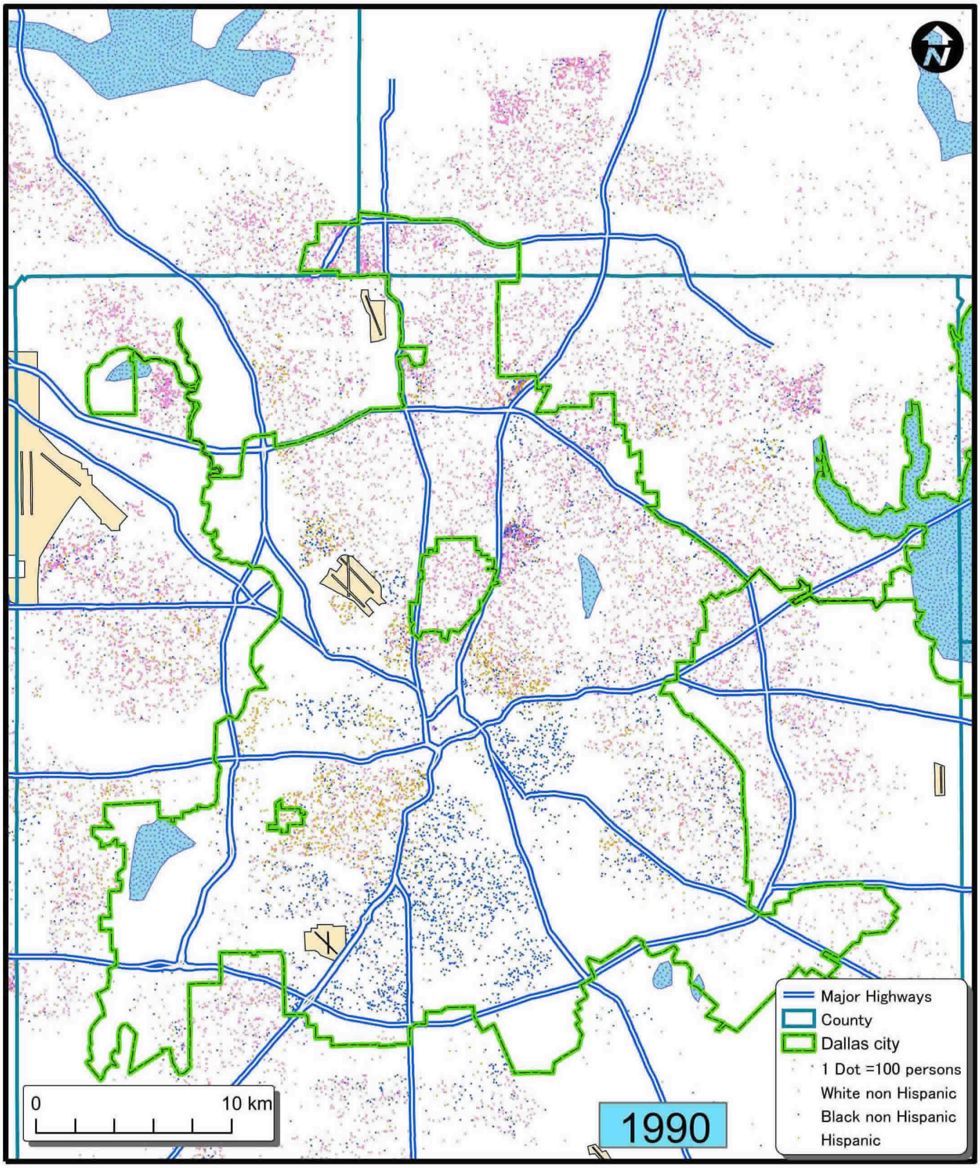

Figure 5 Distribution of major groups (1990)
Based on TAZ spatial unit
Source: CTPP1990

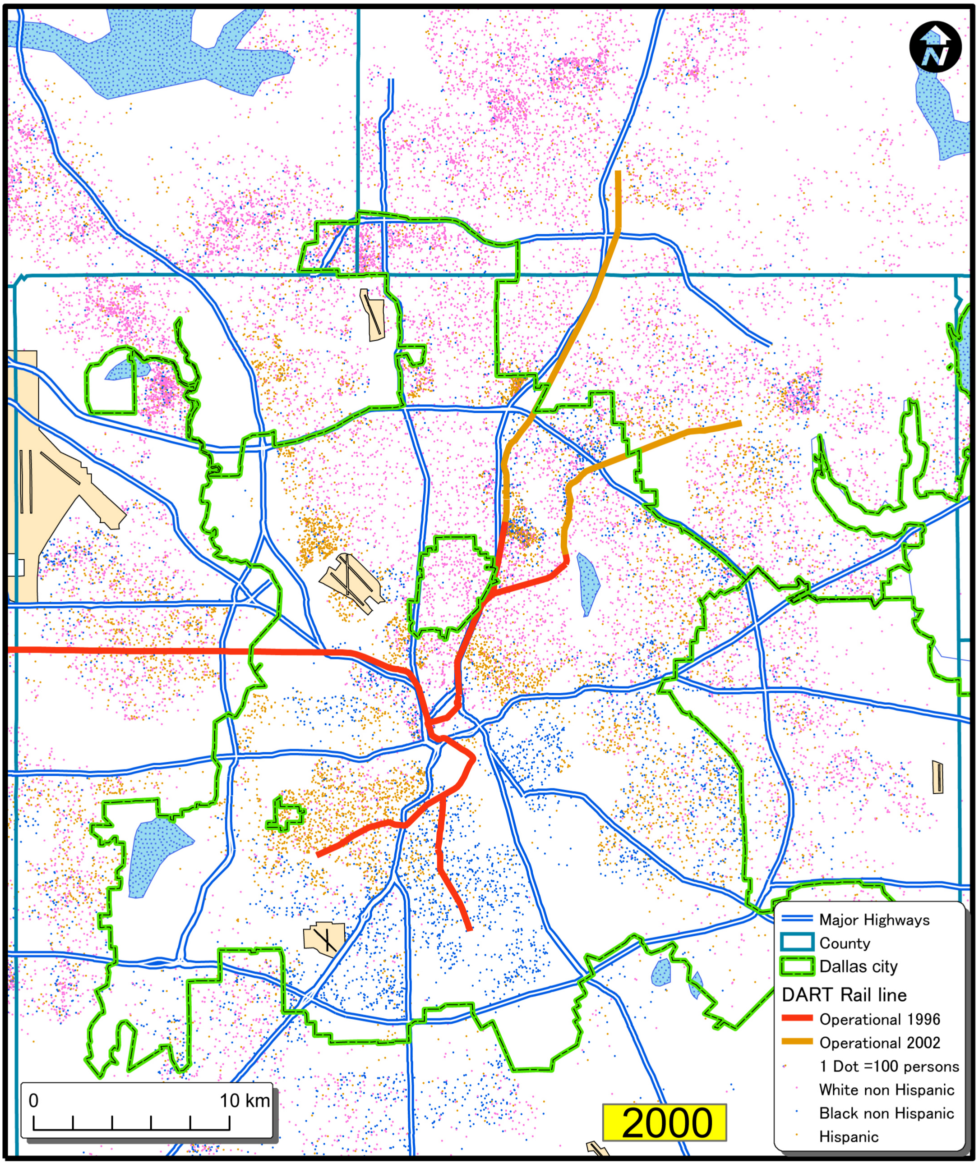

Figure 6 Distribution of major groups (2000)
Based on TAZ spatial unit
Source: CTPP2000

CHARACTERISTICS OF THE CBD AND SUBURBAN DOWNTOWNS

Figure 7 shows industrial, office and retail activities in the Dallas area. Previous investigations such as Garreau (1991), Lang (2003) and the Greater Dallas Chamber of Commerce (2003) are referred to determine the study area. Figure 8 shows a time-series trend of office building locations in the CBD according to ZIP code spatial units. Figure 7 and Figure 8 exhibit distinctive patterns. Dallas's office cores are heavily concentrated on the northern side of the region. But even more impressive is the wide dispersion of the suburban industrial cores (Garland) and office cores adjacent to the intersections of major highways. Especially, in the north and north west axes, where a new DART line will be extended by 2008, relatively younger office buildings, largely constructed after 1990, are creating an so-called 'Edgeless city'. Office buildings predominated downtown until 1969. Then the heart area moved outward gradually and reached the northern Beltway, about 10 km from the CBD (by the 1980s), and extended to even 30km away from the CBD after 1990. The clear trend of office suburbanization is obvious. The distribution of Dallas's retail cores is similar to that of office cores.

Table 2 shows the employment trends in the CBD and some suburban cores in the Dallas area. The definition of the CBD and office core is based on census tracts. The delimitation of office cores in the suburbs was very difficult due to the dispersed nature of office locations in the US, however, the authors identified the major concentrations of office activity according to each census tract based on the land-use map in Figure 7. The total employment level in the CBD is 97,115, or 5.3 % of the total area of Dallas PMSA, while other industrial cores such as Stemmons FWY, Far North Dallas and Las Colinas are nearly equal, or even bigger than, the CBD in terms of employment. High concentrations of administrators and professionals as well as relatively lower number of retail and industrial workers are found in the CBD and Legacy areas where higher income groups are predominant. Industrial cores such as the Stemmons FWY and Garland have relatively lower incomes (lower than the average of Dallas PMSA) due to high concentrations of manufacturing, construction and transport-related workers. NCTCOG (2003) shows that the CBD and major cores expect future employment increases. In addition, the CBD (30,000), Legacy (36,000), Las Colinas (65,000) and the Richardson vicinity (62,000) anticipate population increases from 2000 to 2030. More future growth is expected in the suburban office cores than in the CBD.

The simple pattern of commuting flows in the Dallas area is shown in Figure 9 indicating strong commuting flows to the CBD and intersuburban flows to several self-contained suburban office agglomerations. Figure 9 illustrates the areas which show higher rates (over 10%) of commuting flows to Las Colinas, Plano, and the CBD by census tracts. There are more commuters in the CBD than in the sub-centres, such as Las Colinas and Plano; however, these commuters tend to live closer to the CBD than in particular the north and north-western suburbs where several office agglomerations exist. The commuting areas of Las Colinas and Plano, located in the suburban office agglomerations, had fewer or the same number of commuters as the CBD; however, they both show independent commuting patterns. This characteristic is similar to that of Vance's 'urban realms' where an independent pattern of commuting is based on each suburban core (Vance 1990).

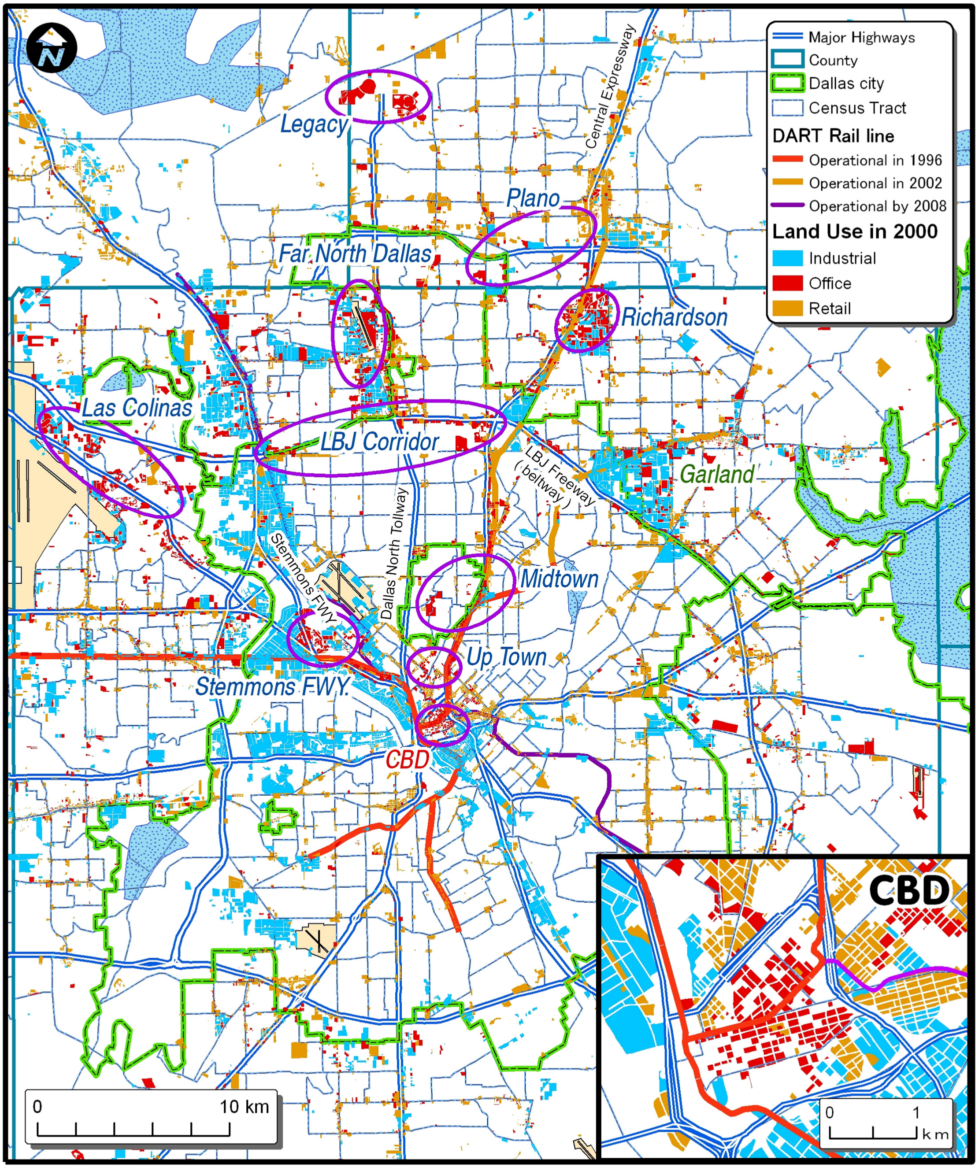

Figure 7 Land use in Dallas area (2000)
Source: NCTCOG

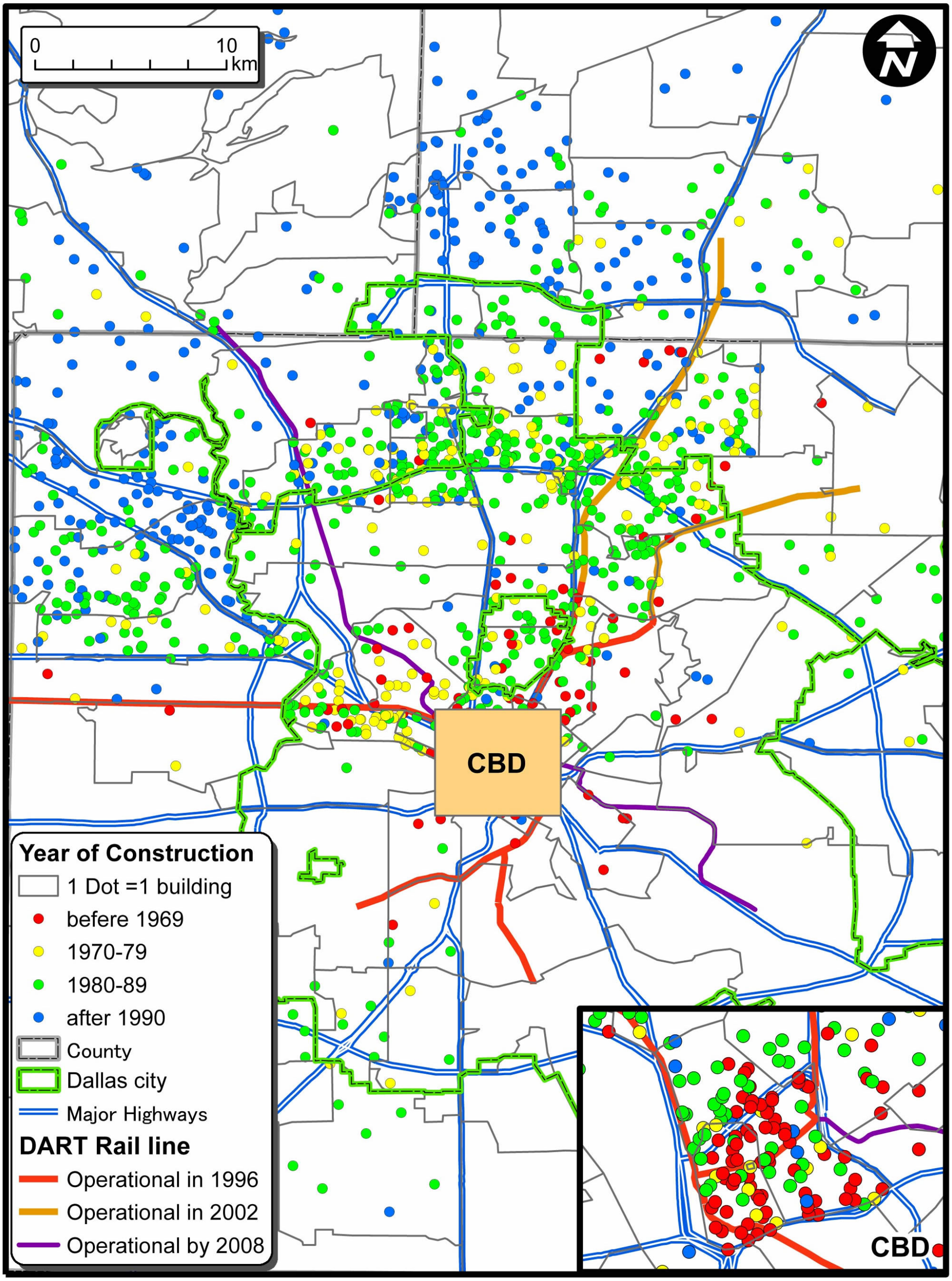

Figure 8 Distribution of office buildings by year of construction
Based on ZIP area code
Source: Dallas office guide 2002 and 2003

Names of office and industrial cores	No. of Census tracts	Total workers (number)	Management, professional, and related occupations (%)	Office and administrative support occupations (%)	Sales and related occupations (%)	Service occupations (%)	Construction, extraction, maintenance, production, transportation, and material moving occupations (%)	Mean earnings: workers with earnings in 1999 (US$)
CBD	4	97,115	49.8	22.8	6.9	10.4	9.9	52,531
Up Town	6	37,150	48.4	17.8	11.3	13.8	8.7	56,402
Stemmons FWY	2	155,045	32.3	17.6	10.0	9.7	30.2	40,820
Midtown	3	33,860	47.9	20.1	12.2	12.7	7.1	52,037
LBJ Corridor	3	44,315	53.8	19.0	11.0	9.1	7.0	53,993
Las Colinas	5	89,490	51.8	23.6	9.6	5.4	9.6	52,544
Far North Dallas	6	93,930	43.5	19.8	15.3	7.6	13.7	50,413
Legacy	1	20,050	65.2	18.7	7.2	3.0	5.9	59,760
Richardson	3	50,960	51.0	15.6	10.0	6.8	16.5	43,897
Plano	4	47,630	38.7	14.3	15.5	11.2	20.2	41,786
Garland	2	35,540	25.5	17.6	10.3	5.0	41.6	37,025
Dallas PMSA	**-**	**1,828,095**	**37.3**	**16.7**	**12.0**	**11.8**	**22.0**	**41,130**

Table 2 Employment in the CBD and major suburban cores in Dallas (2000)
Sources: CTPP1990 and 2000, BTS

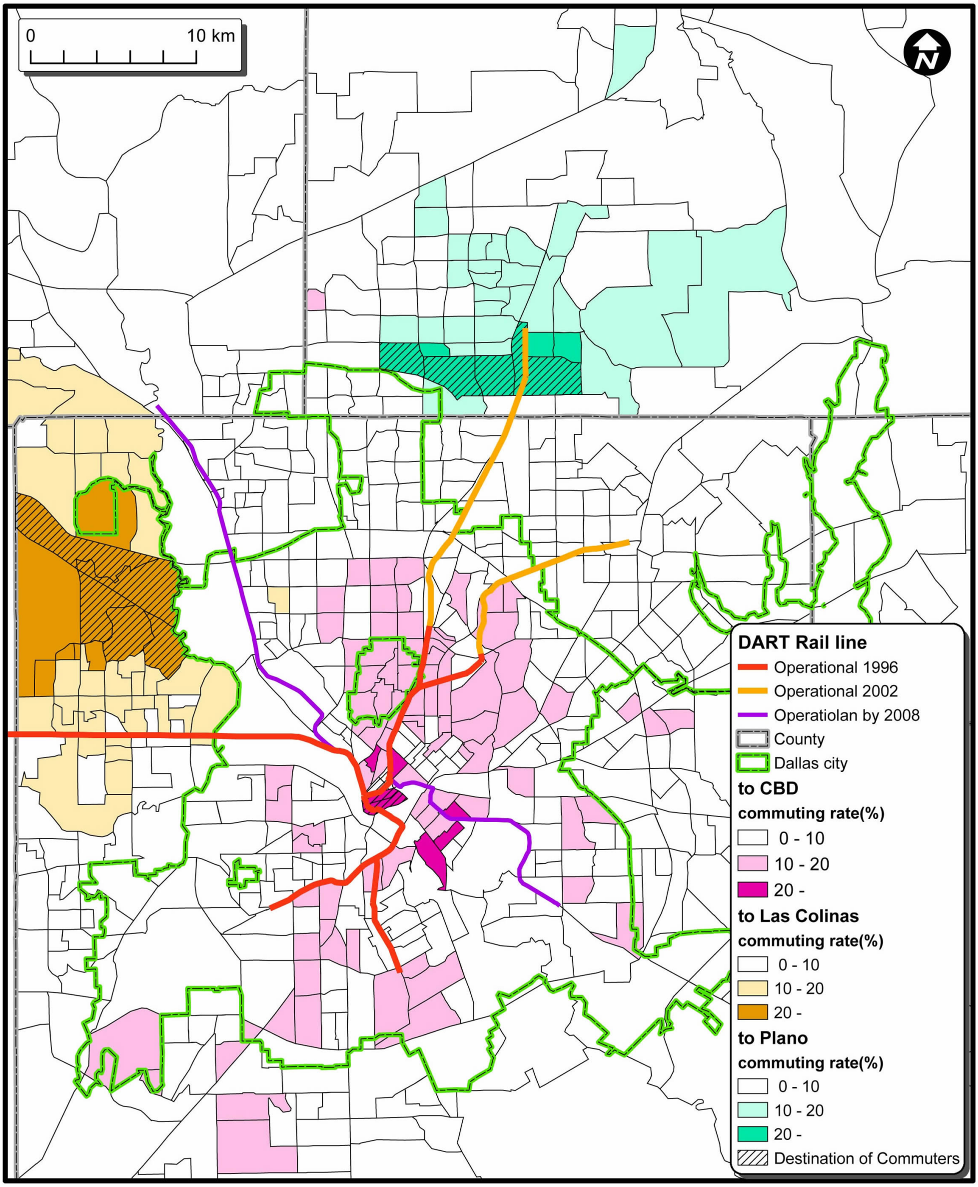

Figure 9 Commuting rate to major office agglomerations in Dallas area
Based on census tract
Source: CTPP2000

OPENING SERVICE OF NEW LRT LINES AND RELATED DEVELOPMENT AROUND NEW STATIONS

THE DART LRT LINE AND COMMUTER LINE (TRE)

The railway and LRT network in the Dallas area is shown in Figure 10. Originally a private streetcar service in the city of Dallas (until mid 1950s) and an inter-city railway (until 1940s) were operated, but were abolished after buses became the dominant public transport service (DART 1999). In 1984, the city of Dallas, in cooperation with the neighboring 13 cities, established DART (Dallas area rapid transit) company following a local referendum that approved using a sales tax to pay for rail operating costs. Until the new LRT line and a new commuter rail (TRE) opened in 1996, the focus of the DART company involved operating bus services and installing high occupancy vehicle (HOV) lanes on freeways.

By 1996, the company opened two different LRT lines: 1) the RED line offered service from the southwest to the north; 2) the BLUE line ran from south to north east cutting through the CBD. Both routes have been extended north / north-east by 2002. The extended part of the RED line was a former railway route connecting the CBD and suburban industrial cores. In the beginning, the TRE began services partially between the city of Dallas and Irving, a western suburb, and extended to the city of Fort Worth by 2001. Although another new LRT route is also projected for completion by 2008, the DART company has a problem in that the recent financial condition of the company is not very good as it depends heavily (about 86 %) on a sales tax for financial support.

Given the successful examples of coordinating LRT and land use control in Portland, OR, and San Jose, CA, the Dallas case deserves attention. Key words for describing the newly extended LRT routes include: former industrial agglomeration and newly growing office cores along major highways. The new routes are projected to connect different social areas in the city: the northern part of the city where the number of employment is growing; and southern part of the city where lower income people or minority groups reside with lower employment shares. The Dallas case also attracts attention due the opportunity to close a social gap and contribute a 'social mix' with transit oriented development around rail stations and reduce construction costs by using discontinued railway lines for extended LRT routes.

SOCIO-ECONOMIC CHANGES IN DART NEIGHBOURHOODS

By using GIS software, population and employment totals within one kilometer radius from each station can be calculated as shown in Table 3. In general, both population and employment levels declined during 1990 to 2000 in the southern part of the city although some stations around the RED line showed a slight increase due to high rate of the Hispanic population growth. On the other hand, in the northern part of the city, both population and employment increased or remained stable along the both lines in the same period. Population increase can be seen along both the RED line (Walnut Hill, Park Lane, Forest Lane and LBJ/ Central) and the BLUE line corridors (Forest/Jupiter and LBJ/ Skillman); these stations are relatively close to the CBD and both LRT lines were extended in 2002. Population increased in these corridors before the new LRT lines were extended. As for employment, the same kind of trends can be seen. The areas showing a big increase are Parker Road, Downtown Plano, Bush Turnpike, and Galatyn Park; all these stations are located at the north end of the Red line was extended in 2002.

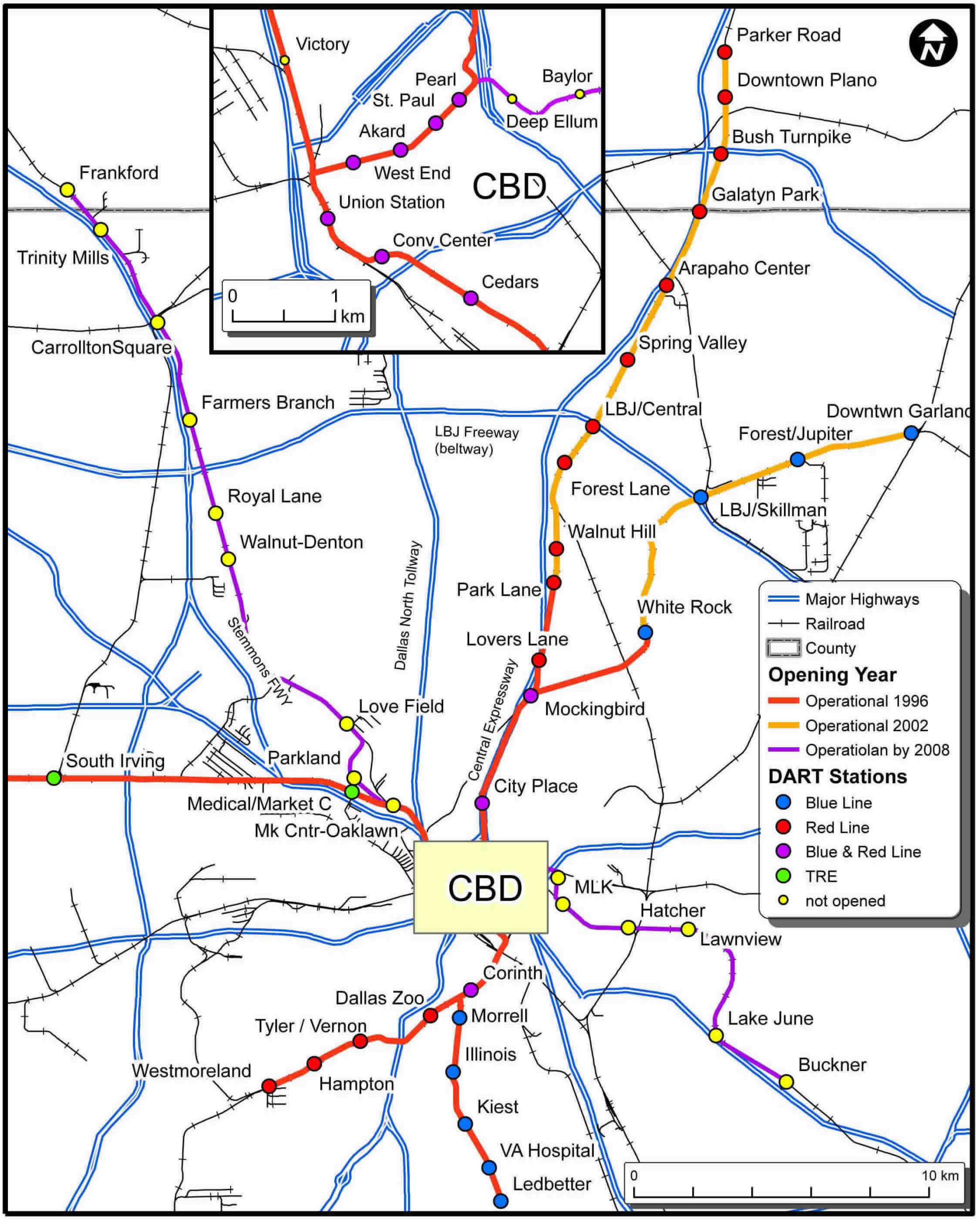

Figure 10 Routes of new public transportation system in Dallas area
Source: NCTCOG

Area	Station	Population		Total workers (place of work)	
		2000	1990	2000	1990
R-N	Parker Road*	6,450	5,138	7,490	4,191
R-N	Downtown Plano*	4,795	3,988	8,985	6,841
R-N	Bush Turnpike*	1,360	1,113	3,265	1,071
R-N	Galatyn Park*	860	700	16,025	4,812
R-N	Arapaho Center*	3,115	2,575	9,960	8,411
R-N	Spring Valley*	3,435	3,398	10,290	9,941
R-N	LBJ/Central*	5,275	3,937	17,120	23,347
R-N	Forest Lane*	6,895	5,289	6,095	6,788
R-N	Walnut Hill*	14,460	8,804	16,130	14,977
R-N	Park Lane	20,865	12,026	13,295	14,610
R-N	Lovers Lane	14,740	13,822	8,840	8,347
B-N	Downtown Garland*	3,290	3,130	5,885	5,590
B-N	Forest/Jupiter*	6,725	4,501	7,665	8,630
B-N	LBJ/Skillman*	9,700	7,415	9,745	9,647
B-N	White Rock	3,330	3,372	995	978
RB-N	Mockingbird	9,440	8,558	8,910	9,377
RB-N	Cityplace	10,130	8,217	11,034	9,213
CBD	Akard	2,839	3,503	95,144	107,182
RB-S	Cedars	1,470	1,625	8,515	9,976
RB-S	Corinth	3,540	3,469	985	1,193
Red Line South (Average : Dallas Zoo - Westmoreland)		8,484	7,175	1,596	2,268
Blue Line South (Average : Morrell - Ledbetter)		4,693	5,201	1,236	1,352
TRE (Average : Medical/Market Ctr. - West Irving)		7,938	5,255	21,525	16,901
Dallas PMSA		**3,519,175**	**2,553,362**	**1,828,095**	**1,396,004**

TRE = Trinity Railway Express (Commuter Rail)
R = LRT Red Line
B = LRT Blue Line
-N = North Part of PMSA
-S = South Part of PMSA
* = not opened till 2000 (opening in 2002)

Table 3 Population and employment changes within a 1km radius of the LRT and TRE stations
Based on TAZ spatial units
Sources: CTPP1990 and 2000, and BTS

Area	Station	Mean Earning, Workers with Earnings in 1999 or 1989 (place of work) (US$)		Management, professional, and related occupations (%)	
		1999	1989	2000	1990
R-N	Parker Road*	39,197	23,495	32.1	29.8
R-N	Downtown Plano*	33,752	23,779	28.2	31.0
R-N	Bush Turnpike*	43,092	25,973	32.7	32.0
R-N	Galatyn Park*	60,698	29,387	67.6	33.3
R-N	Arapaho Center*	48,555	32,516	48.5	43.9
R-N	Spring Valley*	40,580	26,997	39.4	35.3
R-N	LBJ/Central*	57,515	32,622	56.6	47.1
R-N	Forest Lane*	52,961	30,393	55.0	44.1
R-N	Walnut Hill*	45,981	33,520	51.1	40.0
R-N	Park Lane	46,604	30,368	51.3	35.8
R-N	Lovers Lane	44,596	28,289	42.6	37.8
B-N	Downtown Garland*	35,238	23,391	32.3	22.4
B-N	Forest/Jupiter*	41,696	31,217	36.9	40.1
B-N	LBJ/Skillman*	38,050	25,418	26.2	28.9
B-N	White Rock	37,894	26,955	32.6	42.8
RB-N	Mockingbird	40,924	25,478	47.6	38.3
RB-N	Cityplace	48,994	29,628	48.4	34.5
CBD	Akard	54,925	35,138	50.5	42.6
RB-S	Cedars	35,403	25,215	26.9	24.2
RB-S	Corinth	38,217	24,805	44.7	29.5
Red Line South (Average : Dallas Zoo - Westmoreland)		27,670	22,755	31.3	29.9
Blue Line South (Average : Morrell - Ledbetter)		31,355	24,215	37.7	33.4
TRE (Average : Medical/Market Ctr. - West Irving)		35,257	25,429	31.2	29.2
Dallas PMSA		**41,130**	**27,020**	**37.3**	**33.6**

TRE = Trinity Railway Express (Commuter Rail)
R = LRT Red Line
B = LRT Blue Line
-N = North Part of PMSA
-S = South Part of PMSA
* = not opened till 2000 (opening in 2002)

Table 3b (cont'd)

Based on the above overview, the clear contrast of population and employment change is obvious between the northern (major increase) and southern (minor decrease) parts of the city. In addition, the highest employment increase occurred in suburban office cores formerly associated with industrial agglomeration. The employment increase had already started before the LRT line extended into this area in 2002. As in other US metropolitan areas, the new LRT line is expected to serve as a bridge between the employment growth area and the weaker employment area where a greater number of minority groups live.

CHANGES IN LAND USE PATTERNS IN DART NEIGHBOURHOODS

Using GIS readable land use datasets provided by NCTCOG the authors created 1990 and 2000 land use maps and calculated the percentage of each type of land use within one kilometer radius from each station along both LRT lines (Table 4). In the southern part of the city, the land use pattern is very simple. The major land use category is 'single family residences'. The extremely high share of single family residences, almost 60 % or more, was apparent both in 1990 and 2000 at BLUE line stations such as Tyler/ Vernon, Hampton and Kiest.

By contrast, the land use pattern in the northern part of the city is more diverse. No single type of land use category is dominant, as many categories including offices and retails generate land use diversity. The rate of 'multi family residence' is also very high both in 1990 and 2000 at stations such as Walnut Hill, Park lane and Lovers Lane which are located in a section between the CBD and northern Beltway. High rates of industrial land use are seen at stations such as Forest/ Jupiter, LBJ/ Skillman and LBJ/ Central which are located outside the northern Beltway. Retail land use is very common at stations located in the far north (e.g., Parker Road and Downtown Plano). High rates of vacant land use exist at far north stations such as Bush Turnpike and Galatyn Park.

Based on the above overview, several trends in land use change can be identified: redevelopment, prior investment and diversification. The Northern section of the RED line provides a good example. The RED line opened in 1996 but service was limited. The Park lane station was a terminal of the RED line at that time. The section between the Park lane station and the CBD experienced a major increase in multi family residences, office and retail activities. Development at the Walnut hill station (multi family residence), Galatyn Park station (office) and Parker road (retail) occurred in the sections beyond the Park lane station where RED line service began in 2002. A remarkable increase of employment occurred in this section before the opening of LRT service.

Land use change found near the Akard station in the CBD also deserves comment. The dominant characteristic of land use change here is an increase of mixed-use residential buildings. In the CBD of Dallas, some rundown office buildings have been renovated to mixed-use ones. According to Table3, the number of workers who work and live in the CBD increased during 1990 to 2000. The NCTCOG (2003) expects a population increase and emergence of a self-sufficient and livable downtown in the CBD by 2030. The population in the CBD will increase to 16,000 if some redevelopment projects are completed and new jobs created in the retail and service sectors.

STATION name	Year	Residential: Single Family	Residential: Multi-family	Government / Education	Commercial: Office	Commercial: Retail
Parker Road* - Bush Turnpike*	1990	15.9	1.5	1.4	2.3	20.1
(Red Line North : average of 3 stations)	2000	13.5	3.3	7.2	3.9	24.1
Galatyn Park* (Red Line North)	1990	9.1	-	-	12.6	0.8
	2000	11.4	-	0.1	27.2	0.9
Arapaho Center* - Walnut Hill*	1990	15.2	9.6	4.5	5.7	9.5
(Red Line North : average of 5 stations)	2000	14.3	11.0	6.0	9.2	8.8
Park Lane (Red Line North)	1990	3.4	29.0	4.9	7.0	26.2
	2000	5.0	25.8	6.6	8.6	22.4
Lovers Lane (Red Line North)	1990	29.4	21.6	0.9	3.4	7.1
	2000	28.4	22.3	1.4	4.1	9.2
Downtwn Garland* - LBJ/Skillman*	1990	12.0	14.0	5.4	1.6	8.4
(Blue Line North : average of 3 stations)	2000	11.5	9.8	3.9	8.1	8.1
White Rock (Blue Line North)	1990	33.5	3.2	3.6	-	0.6
	2000	33.4	3.2	3.8	-	0.6
Mockingbird (Red & Blue Line North)	1990	29.5	4.4	12.2	3.5	3.4
	2000	29.8	5.4	11.5	4.1	4.7
City Place (Red & Blue Line North)	1990	14.5	11.5	4.0	9.8	11.6
	2000	13.3	13.4	5.4	9.6	9.7
Akard (CBD)	1990	0.0	0.1	13.4	31.7	5.7
	2000	-	1.9	10.9	23.5	5.1
Cedars (Red & Blue Line South)	1990	-	1.8	6.4	0.6	1.9
	2000	0.1	1.2	6.0	0.9	2.2
Corinth (Red & Blue Line South)	1990	31.7	1.5	1.7	0.9	0.8
	2000	28.8	0.9	2.1	2.2	2.4
Dallas Zoo - Westmoreland	1990	50.9	2.0	2.5	0.4	5.9
(Red Line South : average of 4 stations)	2000	48.5	2.1	3.2	0.8	5.3
Morrell - Ledbetter	1990	54.0	1.1	6.0	0.5	4.1
(Blue Line South : average of 5 stations)	2000	51.2	1.8	6.3	0.1	4.7
Medical/Market C - West Irving	1990	17.5	2.2	9.2	6.8	9.2
(TRE : average of 3 stations)	2000	14.7	3.9	9.8	4.6	5.7

TRE = Trinity Railway Express (Commuter Rail)
- = no data
* = not opened till 2000 (opening in 2002)

Table 4 Percentage of each type of land use within a 1km radius of the LRT stations
Sources: Land use map 1990 and 2000, and NCTCOG

STATION name	Year	Industrial	Parking (All)	Under contstruction or vacant	Roads, Parks & Other
Parker Road* - Bush Turnpike*	1990	5.8	-	31.0	26.7
(Red Line North : average of 3 stations)	2000	6.0	0.0	17.0	25.6
Galatyn Park* (Red Line North)	1990	0.2	-	50.6	26.8
	2000	1.1	3.3	30.3	25.7
Arapaho Center* - Walnut Hill*	1990	19.0	-	12.3	30.0
(Red Line North : average of 5 stations)	2000	15.2	2.8	7.3	30.7
Park Lane (Red Line North)	1990	-	-	9.4	20.0
	2000	-	10.3	1.4	19.9
Lovers Lane (Red Line North)	1990	8.6	-	3.0	25.9
	2000	7.0	1.4	2.5	23.7
Downtwn Garland* - LBJ/Skillman*	1990	28.5	-	14.5	22.8
(Blue Line North : average of 3 stations)	2000	26.0	0.6	11.1	23.5
White Rock (Blue Line North)	1990	-	-	-	59.1
	2000	-	-	-	59.0
Mockingbird (Red & Blue Line North)	1990	14.7	-	1.4	30.8
	2000	10.8	4.9	1.1	27.8
City Place (Red & Blue Line North)	1990	-	-	9.9	38.7
	2000	0.5	3.3	1.1	43.7
Akard (CBD)	1990	6.1	-	0.6	42.5
	2000	2.8	13.8	0.1	42.0
Cedars (Red & Blue Line South)	1990	53.7	-	0.6	35.1
	2000	47.5	2.3	1.1	38.7
Corinth (Red & Blue Line South)	1990	5.8	-	8.2	49.4
	2000	4.7	-	11.1	47.8
Dallas Zoo - Westmoreland	1990	13.6	-	6.9	28.8
(Red Line South : average of 4 stations)	2000	7.9	0.4	6.4	29.9
Morrell - Ledbetter	1990	5.6	-	9.1	27.1
(Blue Line South : average of 5 stations)	2000	4.1	-	10.0	26.5
Medical/Market C - West Irving	1990	15.6	-	22.6	25.1
(TRE : average of 3 stations)	2000	12.9	12.5	23.3	23.6

TRE = Trinity Railway Express (Commuter Rail)
- = no data
* = not opened till 2000 (opening in 2002)

Table 4 (cont'd)

DEVELOPMENT AND LAND USE CHANGE AT SELECTED LRT STATIONS

Based on the analysis so far, (re)development, prior investment, and diversification of land use are the key features characterizing the Dallas area. The authors provide here some selected case studies to verify the relationship between the impact of LRT and socio-economic change.[2]

NCTCOG (2003), the developer of the new LRT lines, identified the project timing and the transport supportive land use as important for the new development. For example, "high density" land use, "mixed-use development", and "urban design creating a sense of place and defining location" are very important when the efficiency of the new development is evaluated. Here the authors focused on the changes of land use, ethnic demographics and employment during 1990–2000.

MOCKINGBIRD AND LOVERS LANE STATIONS

The Mockingbird station is located about seven kilometers north of the CBD. This station serves as a junction of the RED and BLUE lines. The Lovers Lane station is located one stop north of the Mockingbird station. Land use around these two stations is almost totally integrated, in other word; the sphere of influence of each station overlaps. In this paper, the authors treat these stations as one node. In 1990, single family residences dominated land use in the area. Many industrial lots existed around the Mockingbird station, while office, retail and multi-family residences were dominant around the Lovers Lane station (Figure 11 and Figure 12). Vacant land use was also found close to the Lovers Lane station. Before the LRT lines were extended to this area in 1996, a railway line in the area connected the CBD and the north-east industrial and office cores (Richardson and Plano cities). Relatively higher income groups predominated in the areas surrounding these stations.

By 2000, the general pattern of land use had not changed: 1) single family residences dominated throughout the area; 2) a combination of industrial, office and retail activity clustered close to both stations; and 3) multi family residences identified with the Lovers Lane station. Expanded parking and office lots have replaced the former industrial area around the Mockingbird station creating a higher density of land use. Retail activity expanded around Lovers Lane station where some vacant lots had existed.

From the viewpoint of social structure, some distinctive changes were identified. In the land use category of Multi-family, which was dominant in the area close to Lovers Lane station, the total population has increased and the ethnic characteristics have changed: the percentage of White residents have decreased during 1990–2000. Hispanic or other minority groups have on the other hand increased. This fact can be identified as a social mix, and the same kind of features are also found in other newly-opened station areas located in the north eastern suburbs of Dallas.

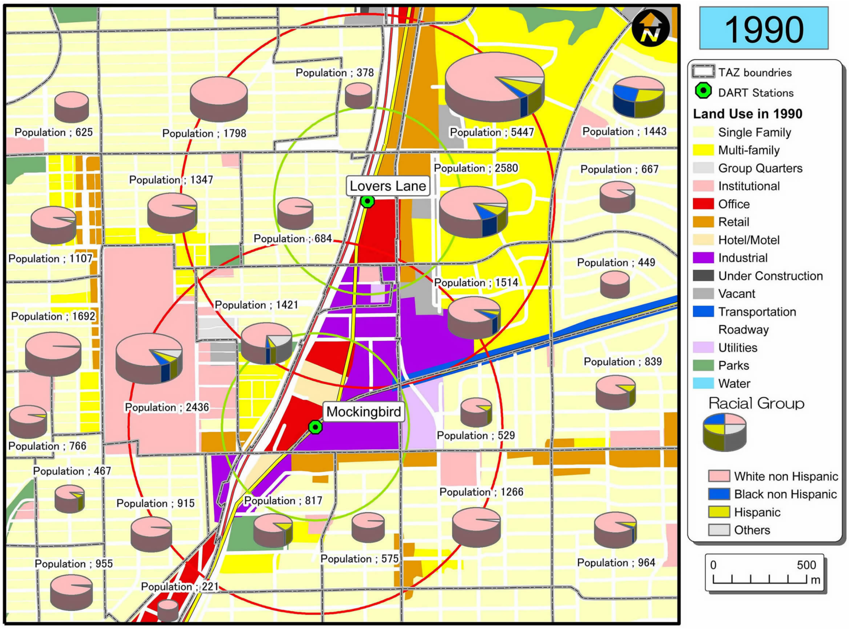

Figure 11 Major groups and land use around Mockingbird/ Lovers Lane stations in 1990
Source: NCTCOG

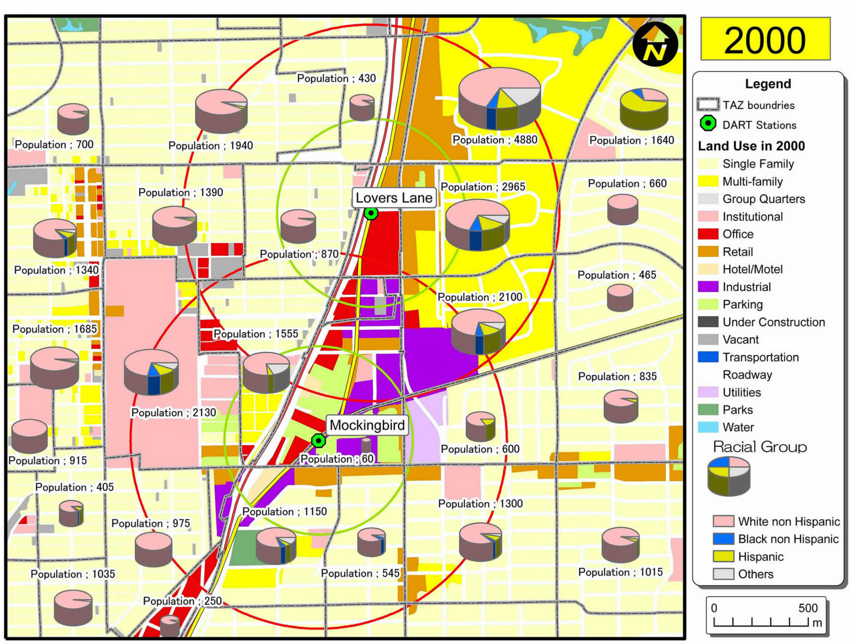

Figure 12 Major groups and land use around Mockingbird/ Lovers Lane stations in 2000
Source: NCTCOG

GALATYN PARK STATION

The Galatyn Park station is located more than 20 kilometers away from the CBD. Suburban industrial office cores such as Richardson and Plano exist close to the station. The RED line extended into this area in 2002. Both land use maps of Figure 13 and Figure 14 show a good example of how intensively the area has responded to prior investments.

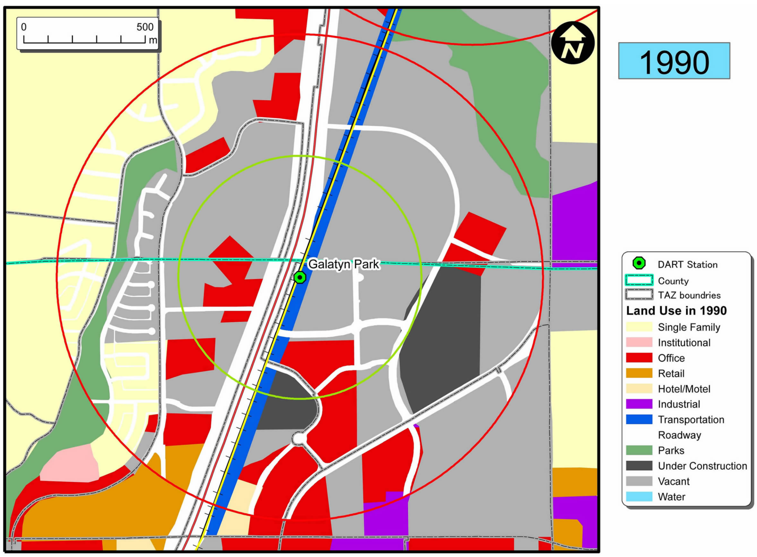

Figure 13 Land use around Galatyn park station in 1990
Source: NCTCOG

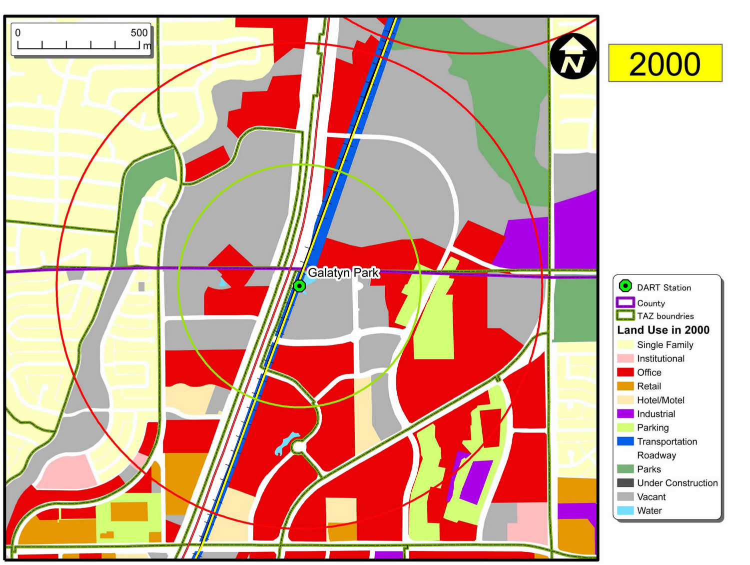

Figure 14 Land use around Galatyn park station in 2000
Source: NCTCOG

In 1990, more than half (50.6%) of the area was characterized by vacant land use. Prior development of offices and other areas of construction were also found around the station. On the western side of the station, single family residence occupied by higher income groups were dominant.

In 2000, although the RED line had not been in service yet, several lots of office development were identified close to the station. The proportion of land dedicated to office increased from 12.6% (1990) to 27.2% (2000), while vacant land decreased from 50.6% (1990) to 30.3% (2000). Most of the newly constructed offices cater to the higher income skilled labour force. NCTCOG (2003) expect that the employment in the area would increase by 42,000 in this area by 2030. Many single and multi family residences catering to office employees are anticipated around the station.

Galatyn Park station area has experienced a rapid increase in employment. The total number of employees in the area was 16,000 in the year 2000, which was about three times greater than in 1990. It is very interesting that most of the office development in the area occurred prior to the opening of the new LRT line shown in Figures 13 and 14.

CONCLUDING REMARKS

Narita (2005) evaluated the effect of new public transportation systems in the American Northeast metropolitan areas, where a "return flow", suburbanites returning to inner city residents, has been dominant. Before the announcement of the development plan for the new LRT lines in Dallas, each of the CBD or the extending suburbs had been developed separately creating a serious problem of social segregation. The new extended lines were designed to correct these social differences. A unique characteristic of the Dallas development was that prior to the opening of the city's new LRT lines, some minority groups had begun to move close to the areas designated for the new stations. Indeed, the new LRT routes connect the CBD and the northern suburbs where remarkable growth in employment can be seen. According to the authors' survey in 2005, some interviewees, including middle to upper class residents, living close to the new LRT stations tended to choose the LRT as their preferred mode of commuting to avoid the heavy traffic congestion synonymous with private car use within the CBD. In general, the development of the new transportation systems, including the proposed sections to be opened in 2008, can be positively evaluated in terms of their impact: creating the so-called 'social mix' by connecting the CBD to the ever growing suburbs. However, the findings of the Dallas case are a little different from those of other metropolitan areas. The population of the entire Dallas metropolitan area has increased but this has been common only in the northern suburbs.

The smart growth policies, aimed at controlling or managing state growth by providing higher density mixed land use, walkable space and a social mix, can be deemed to be efficient when stations located in the northern suburbs are compared to pre-policy station developments. However, the policies have not been effective for the metropolitan area as a whole. Because the increases in job and population are only found in the northern suburbs (while other parts of the metropolitan area remain as before) the social contrast between the wealthy northern suburbs and the depressed southern inner areas is still clear. While DART and NCTCOG, the developers of the public transportation systems, have emphasized the improvement concerns over the environment and heavy traffic congestion, it is still a serious problem that both organizations failed to take into account the social mix of the development areas. It is a worrying prospect that this situation may cause further problems and that the smart growth policies may not correct the existing 'social polarization' problems but instead make them worse in the near future.

The income of the DART company had increased slightly since the new LRT lines opened and the number of people traveling to work by public transportation had slightly increased during the last decade. However, the percentages of people traveling to work by public transportation decreased from 2.9% (1990) to 2.2% (2000). On the other hand, the percentage of people using their car as their only mode of transportation to work increased from 77.9% (1990) to 78.2% (2000). Despite the introduction of the new LRT lines, the increase in employment and population have still been very evident in the ever growing northern suburbs, making serious social problems worse as mentioned above.

The conversion from low-rise buildings to high-rise office complexes, increasing traffic congestion, and other related problems has been very common in the Dallas metropolitan area as in many other major metropolitan areas. Recently new efforts to correct several social problems have been made from an environmental point of view. For example, NCTCOG is now constructing a new outer ring highway as a toll road to reduce the amount of cars in the metropolitan area. In addition, the increase in the number of HOV lanes on the major road networks is generally thought to be a very effective concept. New commuter rail routes across the lower density suburbs are also planned. Thanks for these new efforts, less use of private cars along with more park and ride facilities and higher density development around the public transportation systems can be expected (DART 2003).

In the Dallas metropolitan area, while many characteristics common to other major cities are found, the Dallas case also shows some unique features as both the CBD and the suburbs are still growing. At this moment, it is a little difficult to find any discernable advantages of the new public transportation systems in the Dallas area, because the new LRT network is currently incomplete. When the entire network is fully implemented in 2007, the complete revitalization and integration of public transportation systems, which is a very common practice in American Northeast metropolitan areas, is strongly expected. The utilization of the public transportation systems is the key factor in solving many social problems.

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ENDNOTES

1 The total population of both metropolitan areas are the same; however, the extent of Dallas central city is 2.6 times bigger than Atlanta. The population of the city of Dallas is 1.18 million, which is about three times bigger than that of Atlanta.

2 NCTCOG (2003) noted that high density, mixed-use development, urban design creating a sense of place, and defining location, and the timing of prior investment/ development could be identified as types of 'transport supportive land use'.

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