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SUSTAINABLE LAND USE AND TRANSPORT PLANNING IN URBAN AREAS: A Case Study Of Auckland

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Resource and Environmental Planning at Massey University

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ABSTRACT

In an urban context, our foremost duty as planners is to develop the planning principles and techniques which have predictive value and guide policy with relation to form, function and operation of cities and metropolitan areas.

This thesis examines ways of developing sustainable plans for land use and transportation in major urban areas, with special reference to Auckland, New Zealand. This has been done first, by reviewing prescriptions of urban form, land use and transportation in order to identify sustainability criteria. The key parameters of sustainability are considered with reference to the Resource Management Act (1991), which provides the framework for promoting sustainable management in urban areas in New Zealand.

Second, indicators of urban sustainability for a range of international cities have been compared with figures for Wellington and Auckland urban areas. Finally, the criteria drawn from international literature have been applied to urban land use and transportation planning in the Auckland area, starting from mid-1950's. This review of transport planning studies demonstrates a major shift from policies for highway development and urban expansion to policies for more compact urban form, more efficient land use, and sustainable transportation.

Traditional land use and transportation planning is based on the principle of low density, high speed motorways which foster private transport. Now is the appropriate time to move away from a traditional planning approach and follow approaches which foster sustainability. This means changing traditional transport planning. The focus of transport plans has been traditionally an efficiency and speed. This contrasts with the move toward sustainability.

The way land is used in urban areas is central to sustainable management. In existing major cities, the pursuit of sustainability is limited because of the limited development options available. Change can be pursued, however, by such things as shift in land use patterns, infill development, subdivision, changes toward high density residential areas along major corridors, and converting land uses on major corridors to multi-family residential and mixed land use activities.

The thesis reviews the historic shifts which have taken place in the priorities in transport planning in Auckland. It concludes that there has been a fundamental shift in post-war policy making in the 1990's. An interactive land use/transport plan based on the principle of containment and selective intensification evident in recent work is likely to be the most appropriate model of sustainable development for Auckland. However, it will be a considerable time, before significant changes can be brought about by this strategy alone.

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CHAPTER 1

INTRODUCTION

1.1 TRANSPORT PLANNING AND URBAN DEVELOPMENT

Transport planning is concerned with providing good access while minimising the amount of movement and its cost to society. It emphasises achieving travel cost and time savings for road traffic through the use of land use/transportation models to determine key road network design parameters. The Resource Management Act (1991), under which urban planning is carried out in New Zealand, has a different emphasis on sustainable management of natural and physical resources. This includes achieving an efficient, effective and safe transport system, promoting the sustainable supply and use of energy resources and land, and minimising the adverse environmental effects of urban development.

This thesis investigates transport planning and planning for sustainable development and management in urban areas. Globally, the trend towards living in cities is increasing and consequently problems of urban life are growing. City planners, being the public "custodians" of urban areas, need to develop planning principles and techniques which have predictive value and guide policy with relation to the forms, functions, and operation of cities and metropolitan areas. Urban form and density is widely influenced by the transport system while the shape of the city will, in turn, influence transport planning and investment needs.

Transport is considered to be the most important element in determining environmental sustainability in urban areas (Bonnafous, 1988). Firstly, it consumes non-renewable fossil fuels. Secondly, combustion of fossil fuels is a major threat to our global life support system. There is no doubt that transport activity has adverse effects on the environment at local as well as global level, and has contributed to acid rain and global warming. Despite that, private transport use and fossil fuel dependence continue to increase.

Current trends, particularly increasing car dependency and the growth in road freight, represent a major threat to environmental sustainability. A global total of 400 million cars is growing at the rate of 3% per annum with a commensurate increase in carbon dioxide emissions and other pollutants (RTPI, 1992).

One reason for increasing car use is that the locations of various activities have become more dispersed within urban areas, with greater distances separating homes, jobs and services. People prefer private transport because it provides flexibility, ease of travel to work and other activities. Increasing wealth is closely related to the increase in number of vehicles and their use. Income, therefore, has a significant relationship with the need for land for roads and with congestion, gasoline consumption and environmental emission, due to increased use of private vehicles.

These relationships between transport, land use, and the environment are outlined in Figure 1.1. Increasing wealth increases vehicle use and consequently has a significant impact on the demand for more land for parking and roads. One key outcome of transportation planning traditionally has been the commitment of more land to fulfil parking demands and road construction. Figure 1.1 demonstrates that increasing vehicle use will:

i) further act to disperse land uses through subdivision and low density, decentralised development

ii) set up a cycle of environmental degradation

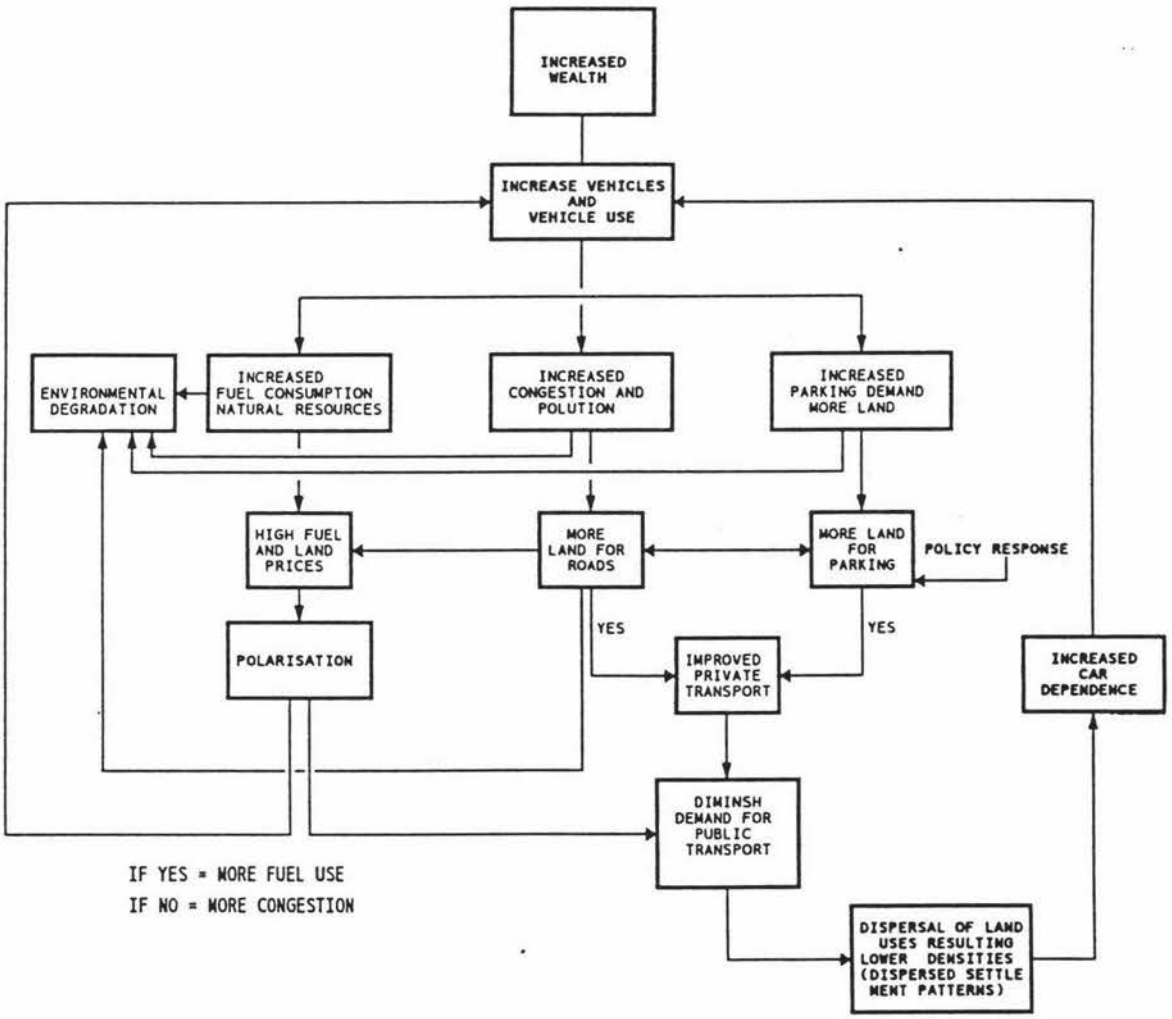
iii) increase pollution

iv) increase fuel consumption and irreversible resource depletion.

Traditionally, urban areas were developed at high densities, providing access by foot between residence and workplace. The development of public and private transport allowed urban sprawl as the dominant post-1920's form of urban development. Initially, suburban development occurred along public transport corridors, and spread to fill the intervening areas with a diffusion of car ownership and use. This dispersal of residential areas changed the spatial relationship between residences and workplace, shops and other destinations, and consequently increased the distances between these activities. The diffusion of private vehicle use was also accompanied by increased congestion and parking difficulties in traditional centres, with some activities pushed to off-centre locations, either outside urban areas, or into suburban areas where there is spare capacity on relevant parts of the road network. Thus, not only has residential development de-concentrated with the new freedom of choice associated with private motor vehicle use, but so have commercial activities and associated employment-creating establishments.

Figure 1.1

RELATIONSHIPS BETWEEN INCOME, VEHICLE, FUEL USE AND LAND USE



1.2 RESEARCH PROBLEM

The overall goal of this research is to develop criteria for sustainable land use and transport planning in relation to energy consumption and urban form by studying Auckland the biggest city within New Zealand. This is done, in part, by comparing Auckland with cities in North America, Australia, Europe and Asia in terms of urban form, transport and energy use, and in part by examining the changing nature of transportation planning and practice in Auckland over the past thirty years.

More specific research objectives include:

1) Identify relationships between urban planning, urban form, urban sustainability and the sustainability of cities;

2) Describe the relationship between urban form and fuel consumption, and evaluate this relationship in New Zealand cities (Auckland and Wellington);

3) Identify criteria which might be applied in urban land use and transport planning to reduce fuel consumption;

4) Assess transport planning in Auckland since 1954 to determine the extent to which plans have fostered urban sustainability through relationship of their policies with sustainability criteria

This thesis attempts to bring together various schools of thought through literature review and empirical methods. An analytical and prescriptive approach based on the literature is adopted to develop principles for sustainable land use and transport. An effort is made to match these criteria with the principles of Resource Management Act (1991). The study also reviews factors

that help to explain urban transport patterns and, in particular, gasoline use and automobile dependence. How far sustainability criteria are reflected in practice will be considered in the context of existing transportation and land use plans for the Auckland urban area.

1.3 THESIS ORGANISATION

The thesis is divided into seven chapters. Chapter 1 introduces the research, objectives, thesis organisation, scope of the problem and information gathering. Chapter 2 gives a brief description of long term urban changes covering urban form, density, and energy consumption in traditional and modern city layouts. Chapter 3 reviews work undertaken on urban sustainability and its relation to sustainable development at global and national levels. Chapter 4 discusses recent approaches to sustainable land use and transport planning. It also outlines the criteria which might be applied in planning for achieving sustainable land use, transportation and city layout.

Chapter 5 comprises the main body of research. It gives a brief description of transport and gasoline consumption at international level. It discusses transport and gasoline consumption in Auckland and Wellington and compares them with other cities around the world in terms of population density, car ownership, gasoline consumption, and population and job distribution .It describes the urban areas in New Zealand with special reference to the changing demography of Auckland over the last two decades.

Chapter 7 evaluates transport planning for Auckland urban area starting from mid 1950's, and presents conclusions and suggests future directions for land use and transport planning practice with special reference to the Auckland Urban area.

1.4 A FRAMEWORK FOR INFORMATION GATHERING

This section of the chapter will describe the specific data required for the research based largely on the work of Newman and Kenworthy (1991). The authors gathered data for their *Sourcebook Cities and Automobile Dependence* covering 32 cities around the world, and then reviewed the choice of data. The Sourcebook does not include any information about the cities of the Third World because of confused mixed transport activity, which includes bicycles, cycle rickshaws, motor rickshaws and animal-drawn transport.

The secondary data collected for this thesis, which came from the Census and other sources, has been used for comparison with the data available in the Sourcebook.

The distribution of the 32 cities according to their total metropolitan population, plus Auckland as the biggest city in New Zealand (1991 population of 939,000) is given in Table 1.1. Of the 32 cities studied, 10% cities are over 10 million population and 21% are under 1 million population.

In the Sourcebook, most of the basic data such as population and employment come from Census statistics. Many countries conduct a Census every ten years. In New Zealand, the Census is undertaken every five years. Nevertheless, it is appropriate to take a minimum of twenty years time period to identify major changes and trends in transport and land use patterns in each of the cities including cities of New Zealand. A partial data-base is obtained for the study area as described in the list of data collected by Newman and Kenworthy for their study (Table 1.2).

Table: 1.1 DISTRIBUTION OF CITIES ACCORDING TO THEIR POPULATION 1991

Population Range	Number of Cities	% of Total
Less than 100,000	7	21
1000,000 to 2000,000	8	24
200,000 to 300,000	7	21
300,000 to 400,000	4	12
500,000 to 1,000,000	4*	12
More than 10,000,000	3	10
Total	33	100%

Note: * Includes Auckland Metropolitan Area.
Source: Newman and Kenworthy 1991

1.5 LIMITATIONS OF DATA COLLECTION

Initially and attempt was made to replicate the Newman and Kenworthy data base for New Zealand cities. However, approaches to Auckland Region, Wellington Region and Hamilton City indicated limits to what was available (2.1). As a result, the scope of the statistical analysis (Chapter 6) was reduced, and the Auckland case study expanded to consider the planning context of urban transportation (chapter 7).

Data collected on vehicles was obtained from the Motor Vehicle Registration Office, which holds annual data on total new vehicles registered, such as passenger cars, commercial vehicles, trucks, motor cycles and others. Data on the total number of vehicles in New Zealand was acquired for the years 1970, 1980, 1986 and 1991.

Statistical information on employment location, land uses and transport activity, and population was derived from the Census of Population.

Per capita gasoline consumption data for major New Zealand cities was obtained from Dr. Murray Patterson, Department of Planning, Massey University, who has built an Energy End-use Database of the New Zealand Economy (Patterson, 1993).

Table: 1.2 STATISTICAL PARAMETERS USED BY NEWMAN AND KENWORTHY

LIST OF DATA USED BY NEWMAN & KENWORTHY	DATA AVAILABLE FOR STUDY AREA
1. **Land Use Data**	
i) Population and area data a) Population (total) b) Actual urbanised area (ha)-(excluding all non-urban uses such as undeveloped or agricultural land) c) Area of the CBD (ha) d) Population contained in CBD e) Inner urban area (ha) f) Population contained in the urban area.	A
ii) Parking availability in the CBD a) Off-street parking spaces b) On-street parking spaces	NA
iii) Employment location a) Number of jobs located in the CBD b) Number of jobs located in the inner urban area (incl. CBD) c) Total number of jobs in the whole metropolitan area	A
2. **Transportation Data**	NA
i) Road network a) Total length of road in the metropolitan area (Incl. all road types from inter-state highways and freeways down to local or municipal residential streets)	
ii) Total vehicles on register a) Passenger cars b) Commercial vehicles c) Trucks d) Motor cycles e) Others (whatever other available categories).	A
iii) Private transport indicators a) Total annual vehicles kilometres (or vehicle miles) of travel. b) Average vehicle occupancy (person per vehicles). c) Average speed of travel in passenger vehicle for whole metro area d) Total annual gasoline consumption for the metro area (incl. LPG) e) Total annual diesel fuel consumption for the metro area.	PA

iv) Public Transport Indicators **PA**

Public Transport Indicators	Annual vehicles kilometres 1970,1980, 1990	Annual passengers 1970, 1980 1990	Average dis. each passenger carried 1970, 1980, 1990	Average speed of travel 1970, 1980, 1990	Annual energy consumption- 1970, 1980, 1990
BUSES o Goverment. o Private					
TRAINS o Subway o Surface o Commuter rail					
TRAMS					
FERRIES					

v) Modal split data **A**

a) % of people taking public transportation for journey-to-work.
b) % of people taking private transportation for journey-to-work.
c) % of people walking and cycling for journey-to-work.
d) Any other modal split data available: eg the above split for CBD oriented work trips compared to other types of work trips OR figures on modal split for other types of trips.

vi) Average trip length **A**

a) Journey to work
b) Other trip types (whatever available) Note that these data include all modes (cars, public transport, and walking/cycling)

Note: **Available (A)**
Partially Available (PA)
Not Available (NA)

Source: Newman and Kenworthy 1991.

1.6 LAND USE AND TRANSPORT INFORMATION

The land use patterns of cities are not only based on population data. They also cover employment and physical area data for different parts of the city (CBD, inner area, outer area and the metropolitan area). This information can be used to derive population and job density information.

The "**metropolitan area**" is defined by Newman as the built-up area which may transcend any number of political or administrative boundaries, such as those of cities and states, but which functionally act as a single, unified region (Newman, 1989). The political and administrative boundary of Auckland is not clearly segregated because the principal city is surrounded by a number of different politically and administratively controlled urban areas. Therefore, Auckland metropolitan area, including all four urban zones (north, west, central and south Auckland) has been included in the study.

The "**inner city area**" is ideally defined as the urban area developed prior to the Second World War. This portion of the city represent the pre-automobile part, having higher densities and in the proximity of public transport facility. In New Zealand context, inner area can be defined as the urban area developed prior to 1945, which includes the CBD.

The land use data required for the purpose of this research includes: CBD area in hectare (ha), inner and outer areas and the density of population (person/ha) in these areas. It is surprisingly difficult to get density of population data. Councils do not necessarily maintain land use and transport data in the required format. The boundaries of the CBD and inner urban area are not formally marked by city councils. However, the CBD area can be differentiated from the rest of the urban area as it is mostly enclosed by major arterial roads. The inner area can be defined as the area adjacent to the CBD. The CBD, inner and outer areas and densities of population contained in them will be discussed in the Auckland Case Study (Chapter 6).

Each city has a different transport pattern and energy consumption behaviour due to its individual urban form. Transport data include a range of information such as: parking supply in the central city; the extent of the road network; vehicle ownership; total kilometres travelled by vehicles; average traffic speed; modes used for various trips (journey to work); average trip lengths for various purposes; and total consumption of gasoline and diesel fuel. Data on key operational features of the public transport system, such as level of service provided, passengers carried and speeds of service is also important.

1.7 PLANNING FOR URBAN SUSTAINABILITY: A CASE STUDY

Transport and land use plans play an important role in assembling the data for the purpose of analysis and comparison of options which influence public investment in transport infrastructure. The nature of this investment, and therefore of the plans themselves, will influence the sustainability of a city through their impact on transport and traffic conditions. A review of past transport and land use plans for Auckland is included as a case study, to determine their relationship with the transport sustainability of the city (Chapter 7).

Since the 1950s, transportation planning has focused on the principles of efficiency in the road network and de-concentration of development to accommodate growth and encourage urban sprawl. The post-war expansion of the region has seen residential areas developed away from social, cultural and economic activities traditionally located in the city center. This pattern of development has encouraged and been fostered by car dependence. Transport plans in the past have increased expenditure on the construction of new motorways in the interest of travel efficiency. The positive side of efficiency is time saving, ease of travel and reduced accidents from high quality roads.

Auckland's modern transportation planning started in the 1950's. It was resolved by the Auckland Regional Planning Authority in October 1954, that its Technical Advisory Committee should undertake a complete survey of the Metropolitan Area's traffic problems and prepare a detailed

report and master transportation plan. The Committee's recommendations, published in September 1955, were based on surveys of traffic flows and the role of public transport in the Auckland urban area. The Master Transportation Plan 1955 formed the basis for motorway and arterial road construction in Auckland.

In 1963 the Auckland Regional Planning Authority commissioned de Leuw Cather and Co., Engineers, of San Francisco to undertake a Comprehensive Transportation Study. The overall objective of the study was to develop a plan and programme for motorway construction, highway improvement and parking facilities for the region. Apart from the Auckland Comprehensive Transportation Plan 1963-65, a number of other transportation studies were conducted between 1965 and 1973 on the basis of the 1964 survey results.

The Auckland Comprehensive Transportation Study was authorised by the Auckland Regional Authority in April 1970 and a Technical Advisory Committee was established in December 1971 to advise on content and methods. The study commenced in March 1973, and was conducted by staff of the Authority's Planning Division with assistance from the Ministry of Works and Development.

The recommendations of the study were made against a background of alternative growth options for future development in Auckland. The emphasis was on servicing urban needs, although the study also reflected a growing concern for the environmental and social problems of urban expansion, the depletion and rising costs of the world's fuel resources, and the high and rising costs of urban transport needs. This situation demanded new methodology and advanced analytical techniques for the detailed evaluation of alternative land use/transportation plans.

The Master Transportation Study and Auckland Comprehensive Study 1963-65 was confined to evaluation of a limited number of land use or network options leading to the publication of a recommended master plan. In contrast, the Auckland Comprehensive Study (1973) was intended to demonstrate the implications of a wider range of possibilities and by adopting a flexible transportation plan for the future growth.

Recent transport studies and policy documents such as the Draft Auckland Regional Policy Statement (1994), Auckland Regional Land Transport Strategy (1994), and Auckland Strategic Planning Model (1994) have been developed within the context of the Resource Management Act (1991). These plans have addressed the issues relating congestion, environmental impacts, fuel consumption, accidents and pollution. The issue of vehicle use in the context of sustainable management of natural and physical resources has been well covered in these plans. The Strategic Plan provides a framework for the development of transport policy over the next 20 years and represent an integrated approach in which infrastructure management and planning measures are combined to overcome current and predicted transport problems. Similarly, the Auckland Regional Policy Statement and the Auckland Land Transport Strategy contain the same approach of infrastructure and management.

All transport and land use plans for Auckland are assessed in Chapter 7 to give an indication of whether those plans were sustainable or not. This review also demonstrates the trade-offs which may need to be made when formulating public resource management policies and allocating public finance to capital works and systems maintenance in the transport sector.

CHAPTER 2

DIRECTIONS FROM THE PAST: THE ORIGINS OF URBAN PLANNING PRACTICE AND THE ENVIRONMENT

2.1 FROM PAST TO PRESENT

This chapter focuses on the various classic planning approaches and the practice of planning, in the modern sense. But to trace its ideological roots, we must go back to the early nineteenth century , in which the vision of a science working in service of humanity first took shape. A Utopian vision of nature sought to design settlements and cities which provided access to the country side. These visions and the designs they gave rise were sensitive to environmental values, but in a large scale society are very resource intensive. Early urban design may be interpreted as a reaction to industrialisation, its excesses and its implications for public health. A reassertion of rural values was reflected in an idealistic design. Planning evolved with a green philosophy based on rural values with urban design based on recreating the rural environment, or enabling people to have ready access to the country side.

Human activity evolves from the basics of searching for food and shelter towards more complex needs of creativity, drawing synergy from involvement in different activities. In a similar way, it is implied, the city should be encouraged to develop organically to support these human needs and the drive towards self-fulfilment at a continuously higher level, where the built environment supports and amplifies positive personal and environmental development (Hill, 1992).

In this chapter different approaches relating to the size, shape and form of cities are examined. Basically these planning approaches revolve around four main categories such as: balanced regional interaction with the natural environment; reconcentration and dispersal, returning the

city to nature; dense urban concentration-technology taming nature; and concentrated decentralisation, with mixed-density development and ready access to green space.

The great visionary architects and planners, provided the future direction to the field of city planning. Howard (1898) anticipated decentralisation of population away from cities; Geddes described "Conurbation" Wright (1934) anticipated the huge impacts motor cars would have on urban form; Le Corbusier (1967) anticipated the importance of new building materials and techniques; and Sim Van der Ryn and Peter Calthorpe (1990) anticipated the importance of a new design synthesis for cities, suburbs, and solar villages. Jane Jacobs (1961) and Friends of the Earth (1993), argue for a new approach to urban planning, based on concepts of decentralised concentration and high density mixed land-use. The phenomena of mixed land-use, decentralised concentration and high density are equally characteristic of ancient walled cities, down-town areas in old cities of the USA, and in old cities around the world. As a demonstration of the durability of the built environment, under favourable circumstances, walled cities are still active parts of urban areas and have been providing for urban living for the last 1000 years and perhaps they may survive for a few more centuries.

The Utopian tradition of planning proposed Garden Cities by building new towns near the existing city to attract residents from the mother town. The Garden City concept implied that when the population grew, there would be plenty of open land in which to locate new towns in the rural countryside at the various nodes network of highways (Figure 2.1). The Garden City Concept is based on the following assumptions:

i) *that the replication of many small towns, each averaging a population of about 30,000, would be a stable arrangement, ie., that most residents would settle for long periods of time in their Garden City and find work there too;*

ii) *that rather than living in large cities, people would prefer to live in a small town close to the countryside;*

iii) *that the decentralised social order made up of more or less self sufficient repetitive units would be intrinsically better than that of a big, centralised city in which many kinds of specialised life pursuits are possible.*

Howard foresaw that the Garden City plan was different from other plans of its era because it emphasised the need to relocate the population away from the unpleasantness of the capital and congestion. He argued that there is a need to start building cities from small settlement units on new sites and creating an urban environment more closely connected to the natural environment.

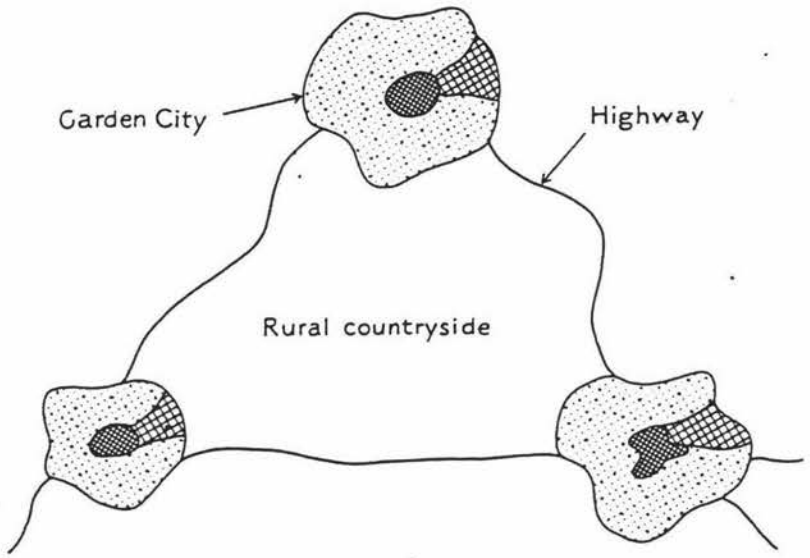
The Garden City concept did not provide sufficient opportunity. The residents were dependent on the nearby town for employment opportunities, specialised civic amenities and hospital facilities. Living close to nature meant sacrificing urban facilities, more travel to get to work and more transportation networks to handle the increased motorised traffic.

The concept of a decentralised social order was idealistic and highly expensive to implement. This form of dispersed development is highly inefficient in energy and resources, especially where people depend on private transport for most of their activities. However, Garden City settlements provide the advantage of having environmental efficient settlements.

The Garden City concept was promoted as an alternative to cities and disregarded the benefits a big city user would get through specialised urban facilities. In a concentrated urban area, most of the infrastructure costs are shared by various land use activities.

Figure 2.1

Typical Garden City



Source: Dantzig & Saaty (1973)

Patrick Geddes (1915) also believed that urban planning needed to build from a knowledge of natural regions and their resources. He regarded the river basin as the natural unit for examining the different activities associated with cities. He also examined the influences exerted by new technologies such as electricity and motor vehicles. He noticed that the sprawling city would dissipate resources and energy and alienate people from nature. It would be important to bring nature back into the city. He proposed that the best city form would be star-like, with axes of natural space or open space introduced into the city.

The phenomenon of "Conurbation" was described by Sir Patrick Geddes (1915) as the process in which unorganised settlements develop continuously along a main highway at some distance from a city. Subsequently grids of endless rows of houses between the radiating highways are developed, closing the gap between the suburbs and the city. This flow of new development makes the central city weak by the flow of its vitality to the suburbs, and turns it to slums (Paul and Percival, 1960). Geddes work recognised that Howard's hope for the propagation of the Garden City was not to be realised. Nevertheless, the concept of Garden Cities influenced all urban planning after 1898.

Greenbelt communities are derived from the Garden City concept. They did not replace the city in the lives of residents, but developed as "bedroom communities", increasing commuting distances from home to work places. These communities consist of rigidly zoned neighbourhoods each surrounded by a "belt" of undeveloped land.

Goodman (1969) described greenbelt communities as:

> *"the communities in which women are neighbourly, they spend ten hours a week playing cards."*

Greenbelt communities are a form of leapfrog suburbia. They were highly vehicle dependant and connected through highways and major arterial roads (Figure 2.2). When these communities coalesce along arterial roads, possibly as a result of weakened administrative control, they may actually encourage urban sprawl, commuter settlement and energy intensive development.

George and Thomas (1973) gave a list of socioeconomic pressures that cause urban sprawl:

i) *Increase in population;*

ii) *Rural to urban migration;*

iii) *Increase in the density of population in urban area;*

iv) *Residential area decay around the city core;*

v) *Increase in economic means resulting movement of inner city residents to suburbs and residents in suburbs to move to larger homes on larger lots;*

vi) *Extension and development of highway system;*

vii) *Industrial relocation;*

viii) *The development of multiple family housing;*

ix) *Rise in urban transportation problems.*

Urban development designed to be sensitive to the environment in the United States ranged from Organic development, based on proposals arising from the low density dispersal of population to proposal for high rise structures. Wright (1934) developed a model of a decentralised Garden City which he called "Broadacres". He argued that:

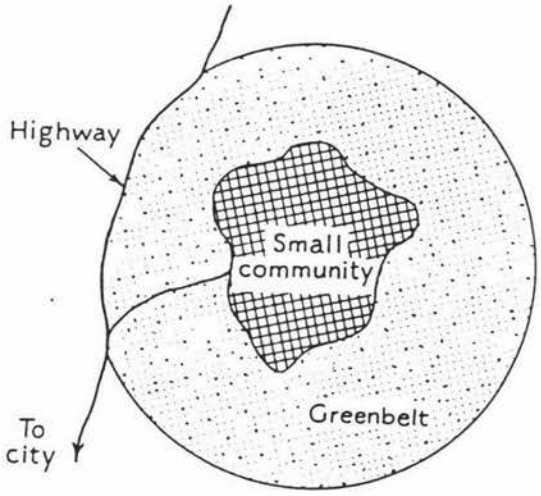
"the traffic problem, if tied up with the skyscraper, is unsolvable by any busy city."

His goal was to open up the city and bring farm values to it by proposing one acre to each family of a community. He believed so much in the importance of urban man's need to be close to the soil that he concluded 'The Living City". It is evident that the Living City model required more roads to link the resulting scattered development and therefore was not energy efficient. The Living City model encouraged urban sprawl and leapfrog development, which is today termed a 'cancer' in terms of the sustainability of natural and physical resources.

The evidence shows that those settlements where people lived closer to nature, were short lived and the chances of sustaining cities on this basis were remote.

Figure 2.2

Typical Greenbelt Community

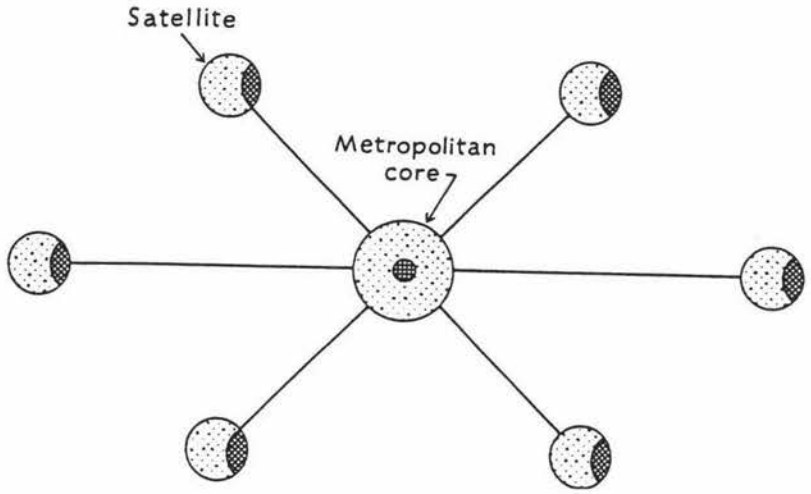


Source: Dantzig & Saaty (1973)

Satellite Cities provide another version of the Garden City movement. They consist of a number of Garden Cities located around a larger central city. The central city would provide the commercial, administrative and cultural center that would be duplicated in the satellite cities (2.3). These activities would provide the opportunity for residents to live and work in the same satellite. The analogy of satellite cities is to living cells, which when separated from the parent body, will replicate the parent (Lynch, 1981). The satellite cities were developed on the principle of Garden Cities which encouraged more roads and commuting to work or shopping. These towns were probably among the first to promote more travel and gasoline consumption for the sake of lifestyle

Figure 2.3

Ideal Plan of Satellite Cities



Source: Dantzig & Saaty (1973)

The French architect Le Corbusier (1967) introduced a new urban planning approach to bring "soleil, espace, verdure" (sun, space, and green) to the city. He tried to cut down horizontal movement and consumption of land while retaining the penetration of nature into urban areas. His plan was based on a few towering skyscrapers, parks and open spaces between them, and high-speed roadways radiating from the center. Le Corbusier planned rural development for the outskirts of cities in a linear city pattern, but he is most famous for vertical development. This resulted in higher densities along with the efficient road network (Figure 2.4).

Le Corbusier was a strong supporter of high density residential and office building. He proposed medium-rise residential apartment blocks, with offices located in the high rise skyscrapers. High density residential blocks were to be the means to improving internal communications and increasing the amount of open space within the city. There is some misinterpretation of his work due to the fact that in practice the ideas were largely unsuccessful. Le Corbusier drew on the possibilities of emergent technologies in developing his views of urban people through creating a new aesthetics for the urban environment. His interests in the importance of a new material and techniques in multilevel residential blocks and the linear city plan reflected his profession as an architect. His major contribution would have been worthwhile if he had proposed high rise residential and office buildings in relation to city needs. His plan however was a major shift from the decentralised, dispersed Garden City or Satellite town towards high density urban form.

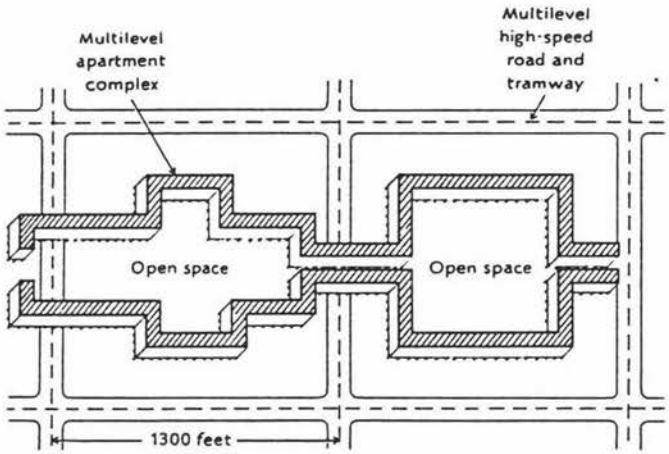
Linear Cities fostered higher densities, but in isolation from the main urban centres. Conurbation processes encouraged the development of radial highways which has largely undermined the Garden City Concept. The Living City advocated by Wright undermined human needs, and was an extravagant use of natural resources, leading to very low density urban form. Satellite cities fostered the development of highway networks, and increased commuting from the satellite to the mother town for work, shopping and other amenities. Basically, satellite cities were developed on the principle of self sufficiency and socio-economic sustainability, but this was rarely, if ever, achieved. At worst, they actually lead to un-differentiated urban sprawl.

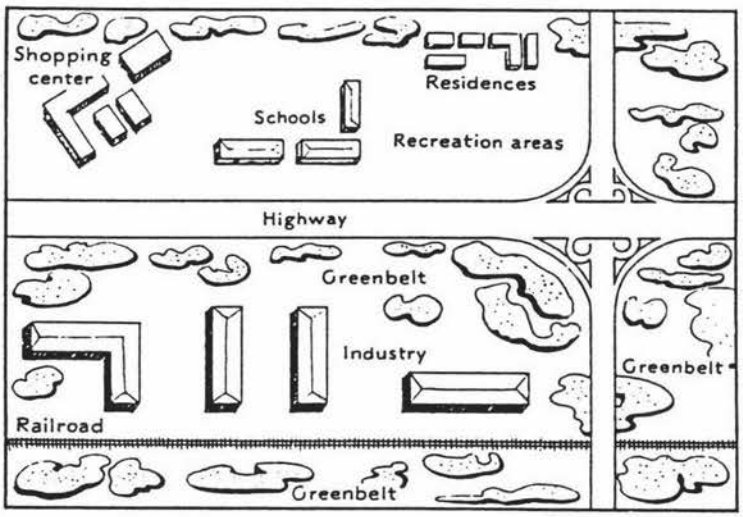
The majority of pioneers in urban design seeking to incorporate natural values in urban communities developed designs which were ultimately inefficient. This inefficiency is highlighted in large scale urbanised society. Only Le Corbusier pointed out towards a significant shift from the development of expensive highways towards high density residential apartments and multi-storey commercial offices without sacrificing the open space favoured by earlier design principles.

In this section we have discussed Garden Cities, Greenbelt Communities, Satellite Cities and Linear Cities. Among all, Garden Cities encouraged low density and high dependence on the transport network.

Figure 2.4

Layout Plan for Multilevel Apartment Complex And Linear City Plan





Source: Dantzig & Saaty (1973)

2.2 LAYOUT DESIGN: THE CLASSIC CITIES

Urban areas provide the structure through which we interact with the environment, both built as well as natural. To make this interaction sustainable, it is necessary to study urban form and the life styles that bring about the interdependence of places and people within the city. Urban layouts affect sustainability in terms of the home/work relationship and the use of natural and physical resources in this relationship within urban areas.

Land-use and transport give shape to the city and reflect life style, production and consumption, travel trends, and socio-economic aspects of urban life. A land use category ideally defines an area of homogeneous activity eg. residential, industrial, commercial, recreational, retailing, and so on. Transportation is defined as the movement of people and goods between land use categories and between places. This movement can be local, inter-regional, inter-state or international. Traffic is the joint consequence of land use activity levels and transportation capability.

This section discusses macro or aggregate patterns of land use and transport as they are represented in different city layouts. It is primarily based on the work of Lynch (1981) who developed city models which were built up from a series, or 'galaxy' of separate medium-sized communities, surrounded by large amounts of open space and connected by arterial roads. He developed principles of urban form bringing together ideas of regional ecological planning and concentrated decentralisation. Under the galaxy of settlements approach, he put forward the notion of the cellular metropolis which was intended to retain the feel of urbanity, the diversity and vibrancy of cultural, economic and social life possible in the city centre.

Lynch (1981) compiled a list of prototype city forms described below:

i) *The Star City*: This proposal is the most appropriate form for any city of moderate to large size. The city should have a single dominant center of high density and mixed use, from which four to eight major transportation lines radiate outward (Figure 2.5). These corridors would contain the mass transit system, as well as the main highways. Secondary centers develop around these corridors. All radiating corridors are connected by the concentric highways, which are free of adjacent development except where they intersect the corridors themselves. Less intensive uses occupy bands farther back from the main radials, and open green wedges take up the remaining space between the corridors.

Figure 2.5

Star City Layout Plan

Source: Lynch (1981)

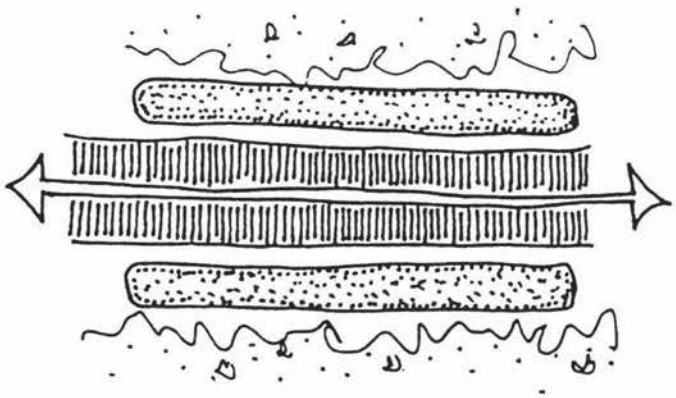
This is a form which appeared spontaneously as formerly compact central cities grew rapidly outward along newly extended public transport corridors. It allows for an active, dense, "urban." main center , while providing for sub-centers and other uses at moderate or even low density. New

development has good access to the main center and to the open wedges between the main corridors. These wedges lead directly out to the rural environs and can provide routes for pedestrians, cyclists, and horse riders. This pattern of development allows the whole town to grow outward (Lynch 1981).

ii) *The Linear City*: This form is developed along the main transport line along which all intensive uses (production, residence, commerce, and service) fall (Figure 2.6). Obnoxious uses and less intensive uses are pushed back towards the rear open areas. This type of city form can be seen in old linear roadside villages and seacoasts or waterways. This form was proposed by Arturo Soriay Mata in 1882 in Madrid. His idea was later taken up internationally, and used in different forms in many theoretical proposals by Le Corbusier in France, MARS group in London, and Frank Wright in his Broadcare City. In the USA, linear development has been renewed as a 'Lifebelt' where activities are clustered at major nodes lined with parking and a greenbelt.

Figure 2.6

Layout Pattern of Linear City

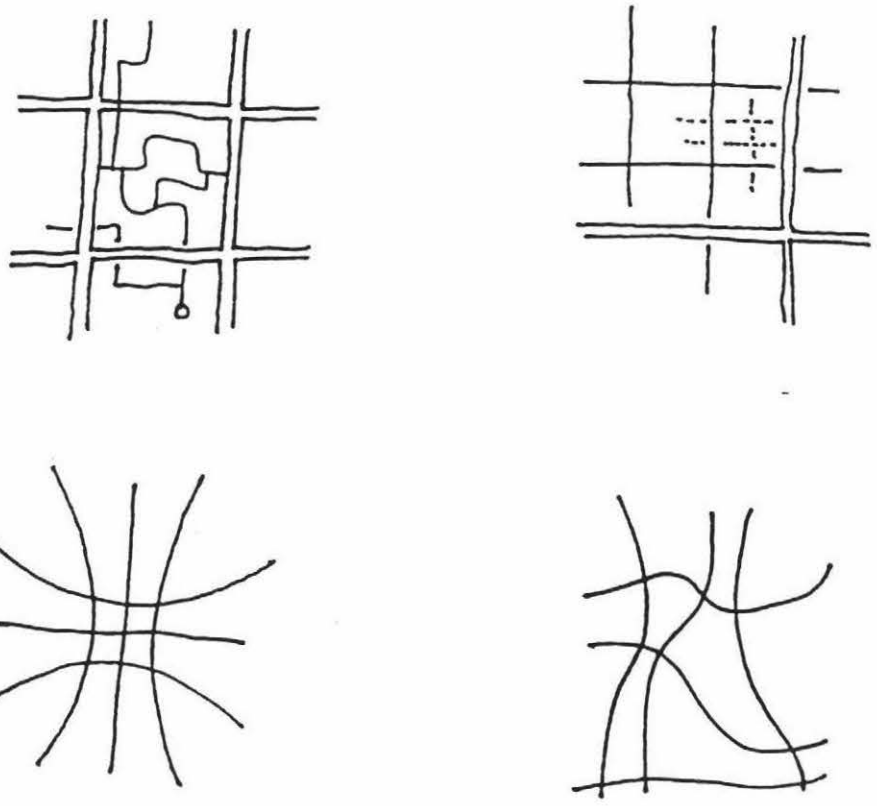


Source: Lynch (1981)

iii) *The Rectangular Grid City*: This city form consists of networks of roads dividing the urban area into identical blocks, and can be extended in any direction (Figure 2.7). Ideally, this form has no necessary boundaries and no central points. The grid form has been used in China, Japan and in more pragmatic colonial foundations, as in Greece, medieval Europe and Spanish America. This form as it-self or in conjunction with some other urban form is evidenced in New Zealand cities such as Christchurch and Palmerston North.

Figure 2.7

Layout Pattern of Rectangular Grid City

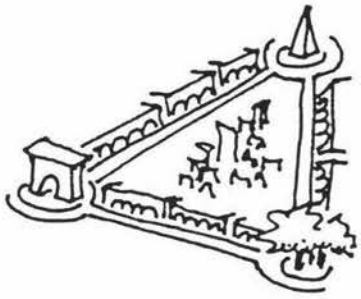


Source: Lynch (1981)

iv) *The Baroque Axial Network*: This form consists of a set of symbolically important and visually dominant nodal points, distributed over an urban area on commanding points of ground (Figure 2.8). It encompasses coherent and well developed ideas about city form, which may organise any complex and extended landscape based on a set of commanding points throughout a terrain and sitting important symbolic structures at those points. These foci are then connected by major streets and shaped as visual approaches to the nodes. Ideally, along these major streets, all the activities including height, facade, and land use are controlled. The interior triangles between the linking arteries are occupied by buildings of varied types (Lynch 1981).

Figure 2.8

Layout Pattern of Baroque Axial Network City



Source: Lynch (1981)

v) *The Lacework*: This urban form refers to low-density settlements in which the traffic ways are widely spaced and the interstices are occupied by substantial open spaces, farmland, or "wild" land (Figure 2.9). This model is like a network of linear settlements, or a blown-up gridwork because of active urban uses along the traffic lines. This type of settlement requires lavish space and sophisticated private transport. It is a very pleasant form in terms of lifestyle but totally dependent on motorised transport and would cause a significant increase in gasoline consumption.

Figure 2.9

Layout Pattern of Lace Model

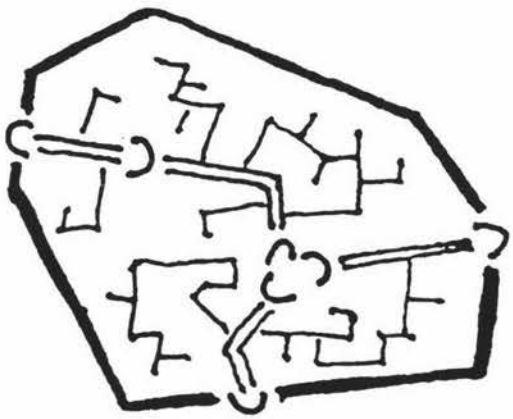
Source: Lynch (1981)

vi) *The Inward City*: This type of urban form is seen in some traditional Islamic cities. The city is enclosed within a wall and gates. The major public ways are tightly confined and lead to smaller local streets, which lead to extremely narrow cul-de-sac like capillaries, which then lead to private doors (Figure 2.10). All the entrance gates are sealed off at night. Such cities have only an initial capacity to deal with motorised transport. The essential characteristics of these cities are described in Stefano Bianca's "Architecture and lebens-form im islamischen Stadtwesen":

> *"Perhaps they are too far from a modern style of life to be useful for us today. Yet they have an undeniable attraction, in their contrast of response and urban stimulus, and in the quality of their spaces. They also have also some thing to say about the techniques of living at high densities" (Lynch 1981).*

Figure 2.10

Typical Inward City



Source: Lynch (1981)

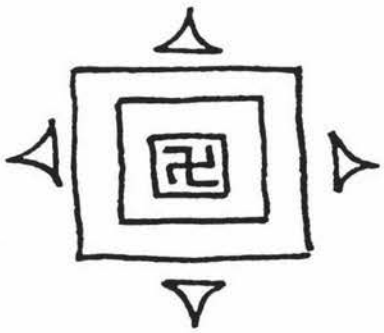
vii) *The Nested City*: This model is a Conceptual model of Hindu planning theory. It has a series of boxes within a city wall like inward cities but in a regular form (Figure 2.11). Each box contains individual occupational groups, as well as a god of the pantheon. The Holy place is kept in the center of such towns and Shudders (lower cast in Hindu society) are kept outside the wall. The important streets are circumferential, not radial, as seen in traditional models. The dominant form and movement is round about, not in and out.

Julian Smith describes the application and present survival of that model, in one religious center (Madurani).

> *"Even more than the Islamic model, these forms seem remote to our lives and purpose. Yet they have lessons, too, if only by contrast, and also because they reveal how links can be made between city form, world view, and ways of daily life" (Lynch, 1981).*

Figure 2.11

Layout Pattern of Nested City



Source: Lynch (1981)

Lynch focuses on the macro patterns of land use and transport planing envisaged by different planners during the nineteen century. He synthesised city layouts which already existed. He translated approaches other than those concerned with the city. He used a variety of ideas from regional ecological planning and decentralisation focussing on efficiency and security.

The challenge for urban planners is to adapt those various city forms to the demands of sustainability. Perhaps, alternative courses of urban development may have to be adopted if sustainability is to be achieved. The new development approach may be based on a fundamental reappraisal of resource use, especially in the areas of energy, transportation, land, materials food and waste. Another alternative could be to redevelop at a scale large enough that a new pattern of activities, and energy and resource use can emerge and begin to change the existing city layouts. This will only happen, of course where there is sufficient growth to sustain the building and rebuilding required.

2.3 RECENT CITY FORM PROPOSALS

Twentieth-century "megaform" and suburban Solar Villages are late versions of the nineteenth-century frontier town, built to exploit the bountiful natural resources (Fuller, 1992). In nineteenth-century suburbs, very little thought was given to location, shared amenities, sense of community, permanence, long term costs, or sustainability. The emphasis was on mobility through motorised transport, with the Garden City a guiding model for early suburban development.

The idea of "megaform" came into practice as a result of the imagination of contemporary designers, in which the city is as one single, vast, three dimensional structure (Fuller, 1992). Roads and utilities are integral parts of this structure, instead of being separate elements, supported directly on the earth. The open spaces of the city occur on the roofs and balconies of houses, factories, and offices. This idea of living at a very high density was proposed to accommodate future population increase and save rural land resources.

These plans are technically intriguing, but costly and complicated and can raise many unsuspected difficulties if implemented. Buckminster Fuller (1992) and others have suggested that cities be enclosed in gigantic transparent bubbles, which let in the light, but protect the city from inclement weather. Such bubbles might be air supported, or be light geodesic domes. Richard Meier (1987) proposed floating cities. These communities might ride the ocean currents, extracting energy from the sun, and food and raw materials from the sea.

2.4 Solar Village Plan

Ryn and Calthorpe (1990) explained the concept of a solar village by saying that the keynote of this plan is sustainability. The Solar Village plan was developed on the following assumptions:

1. The Solar Village as a concept particularly appeals to a large number of people looking to live in a place in whose design and development they can participate directly not only as consumers in the marketplace but as individuals who want to help create their homes, workplaces, the physical and social patterns of the village;
2. The development process must satisfy accepted tests of economic feasibility, but may use progressive financing techniques;
3. The plan does not require major life-style changes. Its features are acceptable to a broad spectrum of buyers in the market;
4. The plan can be carried out without government subsidy.

According to Ryn and Calthrope (1990), sustainability implies balance and permanence:

"i) a balance between people living in a community and the jobs available there;

ii) a balance between renewable resources continuously available locally and local consumption patterns;

iii) a balance between maintaining the natural environment in good health and the needs of the human community which lives within it".

The principle objective of the Solar Village is energy planning at the community scale. A number of different and mutually supportive cost-effective strategies are used such as:

"i) Conservation and solar retrofit of existing buildings;

ii) Passive solar design of all new buildings reducing space heating and cooling demand by 80 per cent;

iii) Solar water heating;

iv) On-site production of gas from biomass resources;

v) On-site electrical co-generation to reduce peak demand;

vi) On-site production of fresh fruits and vegetables;

vii) Convenient alternatives to auto use through pedestrian ways, bike paths, and an internal minibus loop to local employment, schools, and services;

viii) Recycling of water and wastes to agriculture;

ix) Health maintenance through the extensive recreation complex and jogging paths;

x) Community stability through integral neighbourhood design" (Ryn and Calthorpe, 1990).

Communities should be less dependent on fuel and resources as future supply and prices are uncertain, coupled with designing for greater community self reliance and use of local resources to sustain a high quality of life. A model of the Marine Solar Village is Marine County, San Francisco (1979) is shown in figure 2.12.

In modern suburbs or solar Villages increasing density within the residential block goes hand in hand with remodelling to add space and improve energy use, by reducing energy losses and making direct use of the sun for heating. Suburbs along these lines are developed in United States of America and other countries around the world and tested on the basis of the following criteria:

- Utilising residential densities greater than the suburban standard of six to ten dwelling units per acre, or a net density of 75 persons per hectare. This reduces construction and operating costs across the board and, with proper design, opens up the opportunity for a level of social interaction that transcends the isolation of low density and the alienation of high-density suburbs.
- Locating everyday shopping and services so that people can meet their daily needs with greatly reduced use of time, space and expensive energy and with a greatly reduced automobile dependency.
- Building in a local employment base within the community, either by providing for work at home tied to communication and information access tied to computer terminals, or through the location of local employment centers.
- Devising information-efficient and energy-efficient building strategies, including better use of enclosed space and climate-responsive design through building location and orientation, passive solar heating and cooling, lighting, shared use of capital-intensive facilities and energy-frugal appliances and equipment.
- Creating design that encourages the emergence of networks of local people to carry social responsibilities such as crime prevention, fire protection, and home care of children, the elderly, sick and disabled.
- Providing local energy and food production within the community.
- Recycling water and wastes.
- Integrating community design with transportation systems that provide balanced options.

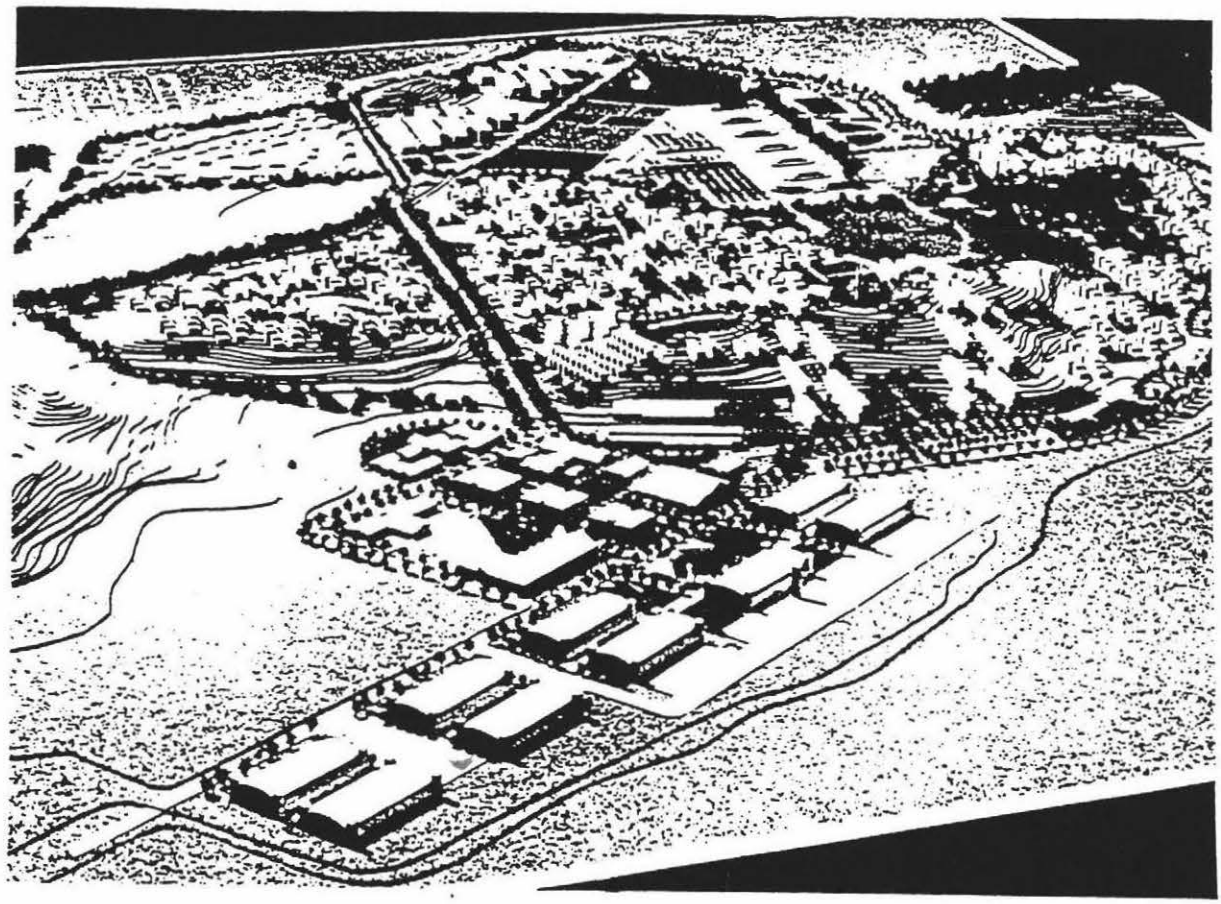
These modern suburbs are not utopian in the classical political or religious sense. They seem similar to the garden city plans, but are based on the principle of ownership and social equity. They are not considered as new towns in the isolated sense, but as suburban infill. They are intended to occupy voids within the metropolitan areas, rather than new sites beyond the existing infrastructure. These modern suburbs are inserting dense, mixed-use reducing pressure for further sprawl, as well as helping reorder the surrounding neighbourhoods. They represent environmental and energy efficient towns that can make growth more affordable to the culture.

The key note of Solar Village Planning is sustainability. It is proposed to achieve sustainability goals through: balance between people living in a community and the jobs available there; a balance between renewable resources continuously available locally and local consumption patterns; a balance between maintaining the natural environment in good health and the needs of the human community which lives within it.

In the actual Solar Village plan, these goals were only partially achieved. Various case studies of Solar Village plans show that 80% of the space and water heating were supplied by the direct solar gain; 30% of the food was grown on site; 50% of the water was supplied from run-off or recycling. In terms of fuel saving, 25% saving in electrical use, and 40% in transportation fuels were calculated (Ryn & Cathorpe, 1990).

Figure 2.12

Layout Pattern of Marine Solar City



Source: Ryn and Calthorpe (1990)

2.5 CONCLUSION

This chapter has outlined different planning approaches relating to the size, shape and form of cities. These approaches revolve around the following four principles:

- balanced interaction with the natural environment;
- reconcentration and dispersal, returning the city to nature;
- dense urban concentration; technology taming nature; and
- concentrated decentralisation, with mixed-density development and ready access to green space.

The macro or aggregate patterns of land use and transport described are based on the work of Lynch (1981), who developed city models based on a series of separate, medium-sized communities each surrounded by large amounts of open space and connected by arterial roads. He developed principles of urban form bringing together ideas of regional ecological planning and concentrated decentralisation. Under this approach, he put forward the notion of the cellular metropolis which was intended to retain the feel of urbanity, the diversity and vibrancy of cultural, economic and social life possible in the city centre.

Twentieth-century "megaform" and suburban Solar Villages are late versions of the nineteenth-century frontier town. In these suburbs, very little thought was given to location, shared amenities, sense of community, permanence, long term costs, or sustainability. The concept of a decentralised social order, based on ideal suburban settlement principles with their origin in the Garden City concept, offered an attractive living environment. However, it is expensive to implement and highly inefficient in energy and resources, especially where people depend on private transport for most of their activities.

Modern suburban settlement layouts were developed on the principle of private ownership and social equity. These layouts are different from the original Utopian city and new town approaches, which highlighted the free-standing status of suburban scale communities, and could lead to a sense of isolation. Modern values, instead, encouraged suburban development within the metropolitan areas. These traditions of planning included the focus on automobile-dependant development, and the diverse city form advocated by Lynch (1981).

The shifts in this history took place not just in terms of urban form, but also in the accompanying institutional and value changes, and most recently encompass new views of the urban environment. The new planning approaches are idealistic. They represent on opportunity for modern planners and engineers to see their dreams come true, and assume the people want to become part of their dreams.

The emphasis of these planning approaches was on balancing interaction with the natural environment by way of reconcentration and dispersal, dense urban concentration, or concentrated decentralisation. They demonstrate and rely on relationships between urban planning, urban form and urban sustainability. The next chapter focuses on the importance of sustainability to identify ways of moving towards urban sustainability, without frustrating positive urban changes.

CHAPTER 3
URBAN DESIGN AND SUSTAINABLE CITIES

3.1 DEFINING SUSTAINABLE MANAGEMENT: LOCAL RESPONSES TO INTERNATIONAL ISSUES

The previous chapter demonstrated the move in design philosophy towards more integrated concern for the environment and communities and a focus on sustainability. However, this has to be underpinned by an appreciation of the constraints imposed on design by existing urban form.

To implement sustainable urban development policies, it is necessary to understand the dynamics of urban development, why certain cities survive and grow and how contemporary forces of urban growth bring about changes within existing urban environments.

The issue of the durability of urban centres is a long-standing one. Archaeological records show that early civilisations existed in south Mesopotamia, Egypt, the Indus Valley, the Yellow River in China, the valley of Mexico, the Jungles of Guatemala and Honduras, and the coast lands and highlands of Peru. In terms of order of origin, Mesopotamia, Egypt and India have been considered to be dead cultures, from which Western Civilisation has developed (Morris, 1972).

To some authors, settlements exist because of their role as administrative centres for territorial control, for their defensive role as a walled cities; and for human and social needs, including the role of close contact in cultural, artistic and scientific development. All the above roles may help foster urban and national economic growth (Richardson 1978).

Mumford (1961) and Colin (1989) have both observed that every city tends to have its one 'golden era' but for many decline quickly ensues. Part of the fascination of twentieth-century urban change has been the attempts of some older cities to 'reinvent' themselves after initially being written off following rapid de-industrialisation. Restructuring policies have been pursued in many older cities

seeking to achieve a second golden era. One of the issues facing urban development today, is not just how economic and demographic factors will influence the growth or decline of a city, but the implications of a city's development on the natural environment and on finite resources.

The definition of "sustainable development" proposed by the Brundtland Report has been criticised in various quarters for providing insufficient grounds to motivate change. Why should people save resources for future generations? How can politicians, planners, and scientists convince the present generation to save resources for the sake of future generations? (Pearce, 1989).

The notion of sustainable development as described by Pearce (1989) identifies three key concepts - environment, futurity and equity. Environment provides the basic component for sustainable development. Awareness of the natural, built and cultural environment has been increased and reviewed in terms of traditional development objectives. A link has also been expressed between environmental quality and quality of life.

Futurity of development decisions refer to the long-term horizon. Long term development guidelines are proposed to replace the past preoccupation with the short term future. Equity is the component which adds for accounts for the less advantaged in society, and also for fair treatment of future generations, termed inter-generation equity. This recognises that the current generation has the right to use resources for a certain period of time, but should hand them over to the next generation for their use, on the understanding that successive generations have an equal stake or interest in these resources.

Pearce et al. (1989) define development as the economic, social, and environmental aspirations of groups, which may or may not have economic growth as a priority. The achievement of these aspirations should accommodate inter-generation and intra-generation equity. Inter-generation equity requires that the stock of environmental resources passed on to the next generation should not inhibit their aspirations and intra-generation equity seeks to increase the likelihood that the current aspirations of different groups will be met. In a nutshell, the underlying principle is that the

stocks of natural resources should not be depleted beyond their regenerative capacity (Pearce 1989).

The theme of sustainability was given impetus by the Brundtland report (1987). Emphasis was placed on development compatible with maintaining environmental quality for future generations. The World Commission on Environment and Development (WCED) produced *"Our Common Future"* (the Brundtland Report). The report emphasised the role of social inequality and poverty in bringing about unsustainable behaviour. The particular problems facing cities were described in terms of the complementary nature of urban and regional strategies and the importance of developing secondary urban centers as a means of controlling the growth of very large problematic cities (Graham, 1994).

As defined by the Brundtland Commission, sustainable development is:

> *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED, 1987)."

The Earth Summit held in Rio de Janeiro in 1992 further discussed sustainability at the global level. This meeting brought global leaders together to confront a wide range of environmental challenges. The resulting programme to tackle these, Agenda 21, provided a center focus for international cooperation and coordination (Graham, 1994).

At Rio, leaders and representatives from over 150 states, developed and developing countries, adopted a declaration committing themselves to sustainable future development. It was stressed that countries should not turn their backs on the growth, but should ensure that the price of growth does not become an intolerable bill for future generations (Major, 1994).

This international "commitment" is intended to be reflected in national and local responses, with local authorities invited to enter into dialogue with their citizens, local organisations and businesses aiming to adopt a local Agenda 21. Community participation in environmental

programmes at all stages is stressed, as is the development of sustainable city networks to encourage international information-sharing on initiatives.

The meeting also recognised the need for comprehensive approaches to urban planning, to base city development on ecologically sound urban design practice. Follow-up meetings to the Rio conference were held in Manchester in 1993 and 1994. The need for sustainable cities was a top priority in the meetings (Graham, 1994).

Few nations appear ready to make the trade-offs between resource depletion and material living standards, or to reduce the rate of growth. Seven years after Brundtland, few countries have made any major change in their planning policies to develop procedures to encourage sustainability (MfE, 1992). New Zealand and the United Kingdom appear to be close to the top of the list because they are environmentally conscious countries. *Sustainable Development: the UK Strategy* (1994) appears to be one of the first practical responses to Agenda 21 and the Earth Summit. This document looks at the challenges the UK will face over the next 20 years. It is a future-oriented agenda, not just for Government but for business, organisations and individual men and women, and is seen as the UK's contribution to the international debate.

The lack of a wider response to international affirmation of the desirability of firm action reflects the difficulty of moving from theory towards a practical path of sustainable development. However, New Zealand's Resource Management Act (1991) may be seen as a major step on that path. It focuses on the sustainable management of the natural and physical environment. 'Management' implies an active involvement in sustaining natural and physical resources. The distinction between 'Management' "sustainable management", as defined in the Resource Management Act, and "sustainable development", as defined in the Brundtland Report has been considered by the Ministry for Environment (1991). The Ministry concluded that the key difference between sustainable management and sustainable development is that the former is only one part of latter. The other parts of sustainable development include social and economic policy objectives (MfE, 1992).

The terms 'sustainable development' and 'sustainable growth' are sometimes used interchangeably, due to their vague meanings. These terms have different meanings and definitions. To grow means 'to increase naturally in size by the addition of material through assimilation or accretion'. To develop means 'to expand or realise the potentialities of "bringing gradually to a fuller, greater, or better state". Growth is a quantitative increase in physical scale, while development is qualitative improvement or unfolding of potentialities (Daly, 1990).

The definitions of 'growth' and 'development' suggest the use of the term sustainable development for determining the operational principles of sustainability. The term development need not imply growth but may refer to processes which can be observed for long periods of time. The definition of 'sustainable development' supports the qualitative nature of the term development as deals with the long-term future needs without compromising the needs of the present'.

There is widespread agreement that there is a need for sustainable development, including sustainable energy consumption and that urban sustainability has an important part to play in this (Collins, 1990). An important point is how to translate this need into practice, how to measure it, and to assess progress towards its achievement. There is still a question as to whether a country like New Zealand is more sustainable now than it was in 1980.

One of the key current issues in the sustainability debate is the volume and effect of greenhouse gases produced by modern society, particularly carbon dioxide (CO2). An international comparison of Carbon Dioxide emissions per capita by Collins (1990) shows that at two tonnes per person, New Zealand produces double the world average of CO2. On a per capita basis, New Zealand produces more greenhouse emission than France, but less than half that of the USA (five tonnes per person), and half that of Australia (four tonnes per person).

Energy used in transportation has a detrimental effect on the environment. In the USA and Australia, low density living and higher car dependency contribute to the high CO2 per capita emissions. In New Zealand, transport-related greenhouse emission contributes 46% to the national total. The effects of greenhouse emission vary from localised direct effects on flora and

fauna to long-term implication for climate change by way of Global Warming. The contribution of Carbon Dioxide to an accelerated Greenhouse effect is a burning issue. There is an extreme pressure to act now, rather than to wait and see (OECD, 1994). Various targets have been set internationally and nationally to control the Greenhouse effect on world temperature and the associated economic and ecological impacts. In 1991 the New Zealand Government announced a target for Carbon Dioxide reduction of 20% by the year 2000 (OECD, 1995).

3.2 THE RESOURCE MANAGEMENT ACT AND URBAN AREAS

In New Zealand the issue of sustainability has been given consideration since 1975. The draft New Zealand Conservation Strategy (1977) gave primary importance to sustainability. The recent Resource Management Act (1991) provides guidelines for sustainable management, which need to be applied to urban areas in New Zealand.

The New Zealand Conservation Strategy defined the term sustainable development as development based on conservation objectives, ie., taking into account social, ecological and economic factors, as well as the long-term advantages and disadvantages of alternative actions. The interest of the preservationist or conservationist is to retain an existing structure because of its social, ecological, aesthetic, and historic importance, which is not recognised by the market. Market forces act strongly on the physical resources of urban areas. Increasingly, however, heritage values are brought to bear to preserve buildings which may have only limited economic value.

The Resource Management Act (1991) focuses on the sustainable management. Section 5 states the purpose of the Act as promoting the sustainable management of the natural and physical resources. It also defines the term "sustainable management", as managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enable people and communities to provide for their social, economic, cultural well-being, health and safety while:-

> *"(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of the future generations; and*
>
> *(b) Safeguarding the life supporting capacity of air, water, soil and ecosystems; and*
>
> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment (section 5)."*

The Resource Management Act is relevant to urban transport in terms of sustainability, and the factors which might contribute toward achieving a sustainable urban transport system. In statutory terms, the transportation planning process is subject to the provisions of the Resource Management Act as shown in Figure 3.1.

Section 23(3) of the Act states that every land transport strategy prepared under this section shall:

> *i) Identify the future land transport needs of the region or district concerned; and*

ii) Identify the most desirable means of responding to such needs in a safe and cost effective manner, having regard to the effect the transport system is likely to have on the environment; and

iii) Identify an appropriate role for each land transport mode in the region or district, including freight traffic, public passenger transport, cycling and pedestrian; and

iv) State the best means of achieving the objectives referred to in paragraphs (b) and (c) of this section".

A recent paper refer for MfE (McDermot and Rae, 1994) interpreted the Resource Management Act as providing direction for promotion of urban sustainability by defining natural and physical resources as including all structures, ie., buildings and other man-made facilities fixed to the land. The Act also provides direction for urban sustainability by defining an environment which includes:

a) Ecosystems, including people and communities;
b) All natural and physical resources;
c) Amenity values; and
d) Social, economic, aesthetic and cultural conditions which affect the above matters (MfE, 1994).

The definition of natural and physical resources is stated in Part 1 of RMA as; land, water, air, soil, minerals, and energy, all forms of plants and animals, and all structures are considered to be the natural and physical resources. Structures can further be defined as any building, equipment, device or other facility made by people and fixed to the land. Urban settlements are considered to be the physical resources including buildings, streets, infrastructure and urban recreational facilities. They concluded that the RMA provides information on urban issues in

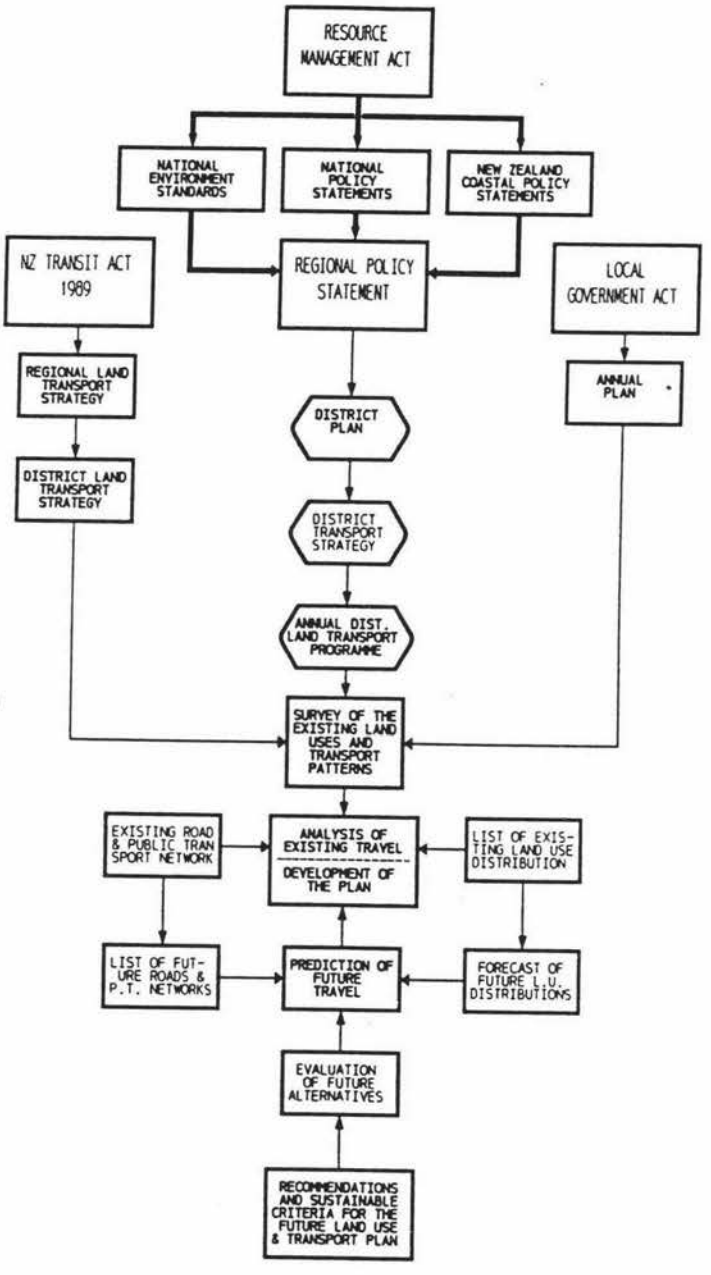
section 7, but does not presume a relationship between urban settlements and sustainable management.

McDermot and Rae (1994) question how far planning is helpful in achieving the efficient use and development of buildings as well as areas. This is an issue of preservation versus flexibility. Preservation implies some merit in retention for its own sake, whereas in urban areas there is pressure for resource "efficiency" pulling down old buildings, to take advantage of opportunities to increase returns using new buildings and more efficient structures (MfE, 1994).

A simple definition of urban sustainability may be inadequate. Aasen (1992) critically explains this notion by assuming that the term management only refers to existing cities and therefore there is no scope for future planning and design. He emphasised that the RMA ignored cities and urban issues and the role they play to our societies. He also pointed out that it is not clear from the Resource Management Act that urbanism as a way of life in New Zealand is at all important. To have viable and sustainable cities, there must be strong cultural desire to have such cities. He believes this probably does not exist presently in New Zealand, because of a very poor appreciation of cities and a weak cultural desire to have cities. In contrast, McDermot and Rae (1994) interpret that urban areas are of considerable importance under the Act.

Figure 3.1

STATUTORY FORM OF LAND USE AND TRANSPORT PLANNING PROCESS



3.3 URBANISATION AND SUSTAINABLE DEVELOPMENT

Cities not only support various levels of functional specialisation in terms of socio-economic and cultural facilities, health care, education and retailing, but also provide a well-spring of innovation, resulting from the richness of social interaction which in turn results from the very fact that so many people live and work in such a close proximity (Jacobs 1984, Bairoch 1988). It has even been argued that 'without cities there could have been no real civilisation' (Bairoch 1988). The Commission of the European Communities (1990) claims that it is a combination of economic, social, cultural and political dynamics which stimulate urban formation and growth.

Global urban population is projected to increase by 1.2 billion between 1980 and 2000. It is estimated that by 2025, there could be up to 4.7 billion people living in urban areas, approximately 3 billion more than in 1980. If this trend continues, 60 per cent of world's population would be living in urban areas by 2025. The impact of such a fast growth in urban areas is a big threat on natural and physical environment (Edward Leman, etl, 1991).

Some consider cities as parasitic on their hinterlands and therefore unsustainable. Berg (1990), argued that:

> *"Cities are not sustainable because they have become dependent on distant, rapidly shrinking sources for the basic essentials for food, water, energy and material. At the same time they have severely damaged the health of local systems upon which any sensible notion of sustainability must depend. In addition, the social systems that make cities livable, such as a sense of community and wide civic participation, are typically eroded rather then strengthen" (Peter Berg 1990).*

Nevertheless, there are commentators who believe that city greening is a sustainable type of development:

> *"A green city is a living city by definition. It is an existing city, where the full potential of the intricately interconnected forces of nature are realised. In a sense, a green city is complete in its survival capacity" (Mayur, R 1990).*

A number of commentators have emphasised the potential for changing the internal economic, social and spatial organisation of the city. This approach involves transforming existing large cities, which have evolved physical characteristics which run counter to the imperatives of sustainable development. Friends of the Earth (1991) argue that:

> *"sustainable urban development must aim to produce a city that is 'user friendly' and resourceful, in terms not only of its form and energy efficiency, but also its function, as a place for living" (Elkin, McLaren and Hillman 1991).*

The World Health Organisation (1992), emphasised:

> *"sustainable urban development' should have as its goal that cities (or urban systems) continue to support more productive, stable and innovative economies, yet do so with much lower levels of resource use" (WHO 1992).*

Breheny (1990) suggests that urban sustainability involves:

> *"the achievement of urban development aspirations, subject to the condition that the natural and man-made stock of resources are not so depleted that the long-term future is jeopardised" (M J Breheny 1990).*

The USA is considered the giant in terms of resource consumption. Statistics show that while it accounts for only 6% of the world's population, the country consumes 35% of its resources (Aasen, 1992). Perhaps, the United Nations Council for Human Settlement can convince developed countries to change their pattern of resource consumption and allow more consumption for developing countries to improve their quality of life at the same time as they pursue sustainable environment.

The United Nations Commission on Sustainable Development (CSD) is monitoring progress on Agenda 21. It was emphasised in its meeting held in New York in June 1993 that a bottom-up approach is required to achieve a more sustainable pattern of development throughout the world. Progress has to be made toward an agreement between countries to establish a framework for action to reduce the risk of global warming and protect the environment. The success of Agenda 21 requires agreement between developed and developing nations to work together to curb the wasteful use of natural and physical resources. The goals and agreement set out in the Earth Summit are likely to be difficult to achieve because they require close agreement between developed nations and developing countries.

In terms of sub-urbanisation and sustainable development, the low density urban sprawl is frequently seen as the worst kind of urban structure. The low density sub-urban development is causing social stratification, high fuel consumption, space devoted to car parking, environmental costs and a high infrastructure costs. The purpose of the Agenda 21 and goals and agreement set out in the Earth Summit is to motivate towards a sustainable environmental and urban development by developing a set of rules, which is universally accepted.

3.4 URBAN SUSTAINABILITY

A city is conceptualised as a place where lots of people and their activities are concentrated in a human environment of diversity and vitality. If that is not the case, it is pointless to live in a city. (Sherlock, 1990). The Association of American Geographers described the city as characterised by a high density population (1968), a place where a high proportion of the land is covered by

structures and pavement. There is a tendency toward air and water pollution, and a concentration of inter-personal and inter-group problems. Cities can be classified and defined; legally and administratively, on the basis of minimum population threshold, and in terms of function, density of population, land coverage and intensity of development.

Dantzing and Saaty (1973) say that at the elementary level, a city should be so structured and organised that it meets:

"i) man's physical needs;
ii) man's love of nature;
iii) man's need for social life and social care;
iv) man's need for growth".

A traditional definition of urban areas given by Gallion and Eisner(1980) refers to " a composite of cells, neighbourhoods, or communities where people work together for the common good." In another definition urban areas are defined as "locations where there is opportunity for a diverse type of living environment and life styles. People live, work, and enjoy themselves, in social and cultural relationships provided by the proximity of an urban area"(Gallion and Eisner 1980).

Sustainability highlights the importance of urban settlements in relation to development and its effects on the environment. There are three reasons for pursuing urban sustainability according to Asen:

1) urban settlements are the primary users of resources (natural and physical);
2) they influence how resources are used and ;
3) they provide an institutional framework for the analysis of sustainability.

Urban settlements are central to sustainable development because they are substantial resource users. Environmental challenges will be greatest in urban areas. Some of the challenges identified by Graham & Colin (1994) are:

> *"i) The increased capacity of the human race to provoke adverse environmental change on a truly global scale - something to which urban populations make a major contribution;*
>
> *ii) The increased size of cities, in terms of both their population and land consumption, which has intensified adverse environmental impacts, particularly on a regional scale;*
>
> *iii) The accumulation of different historical additions to the built environment and social and economic life has given cities an ever more clearly defined, and often more fragile, environment of their own;*
>
> *iv) The rise of the automobile has added to environmental decay in most cities, many of which face difficulties in physically absorbing the demands placed on them".*

Graham and Colin (1994) define a sustainable city as one:

> *"in which its people and businesses continuously endeavour to improve their natural, built and cultural environments at neighbourhood and regional levels, whilst working in ways which always support the goal of global sustainable development."*

As cities continue to grow in size and in their share of the growing global population and economic wealth, the environmental impacts of cities will be a central theme in the move towards global sustainability. Box 3.1 summarises the key environmental issues associated with cities.

One view see cities as undesirable places in environmental terms, not only because they are polluted, degraded places in which to live, but because they foster lifestyles which are energy-intensive (Endean 1993). The environmental impacts and economic wealth associated with the growth of global cities contribute to unsustainability. The Commission of the European Communities (1990), suggests that:

> *"Cities can act as early warning indicators of more deep-seated, broader-reaching environmental crises too, since problems often emerge there more quickly, more intensely and more acutely than elsewhere (Commission of the European Communities, 1990)".*

The Friends of the Earth (1990) argued that environmental issues have increased dramatically since 1988 because very little attention has been paid to urban areas. Urban sprawl has been condemned and urban development described as a 'cancer on the landscape' but no serious attempt was made to critically examine the urban environment.

In his cross-national evolutionary analysis of urban innovation, Nijkamp (1990) focuses on innovation as a key mechanism for urban change. "Innovation" is interpreted as the set of new activities, life styles or institutions brought into being in order to solve serious problems related to city life (Nijkamp, 1990). He argued for the need for the long term adjustment of an urban system in response to internal and external problems to ensure survival in a competitive system of cities:

> *"The new system of adjustment mechanism may require an orientation towards qualitatively different and new functions, forms or roles of the city system concerned, so that sustainability is based on reliance regarding dynamic urban changes (Nijkamp, 1990)".*

Box 3.1

CITIES AND ENVIRONMENTAL ISSUES

i) *42.6% of the world's population was urban in 1990: 72.6% in developed countries, 33.6% in developing countries;*

ii) *60% of the world's gross national product is produced in cities;*

iii) *65% of cities with over 2.5 million people are coastal, several already at or below sea level;*

iv) *On average, each city of one million people daily consumes 625,000 tonnes of water, 2000 tonnes of food and 9500 tonnes of fuel, and generates 500,000 tonnes of waste water, 2000 tonnes of waste solids and 950 tonnes of air pollutants;*

v) *Urban population in different countries vary hugely in their environmental demands. Urban residents in developed country cities generate on average 0.7-1.8 kg of domestic waste daily, compared with 0.4-0.9 kg daily in developing countries.*

vi) *In the USA, almost a third of urban land is now devoted to the needs of the car.*

vii) *Idling car engines in traffic jams in the USA in 1984 alone accounted for 4% of petrol consumption.*

viii) *Land loss has become a pressing problems: in Egypt, for example more than 10% of the most productive farmland has been lost to urban encroachment over the past three decades. In many Western European countries it is estimated that 2% of agricultural land is being lost to cities each decade"*

Source: Graham and Colin, 1994

While acknowledging the importance of sustainability and the Bruntland Report, Nijkamp focuses on the dynamics of urbanisation and the durability of cities in their own right, rather than their relationships with the physical environment. Continuous change is a characteristic of socio-economic development and need, creating or calling for new dimensions to cities, new urban functions, and new form or roles of the cities. Today, the acknowledge that the impulse to survive in a competitive world is accompanied by a struggle for better cities and urban areas in terms of safety, convenience, beauty, efficiency and environment. The challenge is to find ways and means to meet and motivate dynamic urban changes at the same time as enhancing new moves towards urban sustainability.

3.5 URBAN FORM, STRUCTURE AND DENSITIES

Orskog and Snickars (1989), examined "whether the ecologically sustainable city has a different spatial form from the economically, socially, or politically viable city". They did this by estimating the relative prospects for changing different parts of cities. They point out that there is little possibility of change in the city core because of the sheer scale of investment already made and the slow rate of change in infrastructure. There are greater prospects for changes in the outer parts of cities, in the suburbs, and at the urban fringe. Urban fringes are especially important to sustainability as they "resemble the ecologically important shorelines where land meets water".

Orskog and Snickars focused on the question of increased greening of urban areas which goes against the policy of high urban density. They apply this general sustainable criteria in the planning of Greater Stockholm to answer the question:

> *"how to allocate new built-up areas so that contacts between different areas of economic and social interest are supported, as well as to guarantee the functioning of ecological systems to support life in the city".*

Three major options are considered:

i) creating a compact city by building in the green-finger areas;
ii) expansion into existing suburban areas along the radial routes;
iii) to focus more on the towns within Stockholm's hinterland, with better access between them.

The emphasis is on achieving an appropriate balance. Travel can be reduced by increasing urban densities, but this must be weighed up against the need to respect the ecological 'carrying capacity' of cities. "An important issue concerns the scale at which this balance has to be required. Is it within cities, or is it within a city region?" (Orrskog 1989). The authors acknowledge that greening of urban areas seems like a modern version of Howard's Garden City. It has the following characteristics:

"i) a moderately dense urban system, composed of major cities and with satellites that accommodate most of the growth;
ii) with intervening open areas of sufficient size to be agriculturally productive;
iii) with high levels of accessibility;
iv) with facilities for recycling;
v) with Combined Heat and Power (CHP) systems and ambient energy sources; and
vi) sufficient greenery in all areas to remind everyone of their reliance on nature".

Owens (1986) also emphasised the degree to which environmental issues are urban in origin. She focused on the relationship between energy consumption, urban form, and planning, reviewing a range of possible energy-efficiency measures in urban areas, from the most local interurban scales through to a consideration of strategic land use and transport planning. She considered the merits of layouts and orientation in making optimum use of solar gain and microclimate conditions. She

estimated that 70% of delivered energy to an urban area may be subject to the influence of land use planning.

However, she focuses less on the issues related to urban form and moves on to the resource consequences of the functioning of cities. She argued that urban areas are always net consumers of resources and major degraders of the environment, simply because of the relative intensity of economic and social activity in such places. While absolute urban sustainability is impossible to achieve under these circumstances, it is still worthwhile to seek a greater degree of sustainability in urban areas.

An important question, then is "*how to reduce resource inputs to urban areas and how to limit the effect of areas without unduly diminishing the quality of life within them*".

The relationship between urban densities and travel behaviour suggests that by reducing necessary travel distances and facilitating public transport, high urban densities do correlate with lower fuel consumption (Owens 1989). However, high density can also result in congestion. Consequently she concluded that *decentralised concentration might be the most efficient form of urbanisation, with a number of high density centers functioning within the urban area.*

Owens links urban form and energy use:

> *"i) inter-separation of activities can change trip requirements, especially length bringing energy demand variations of up to 130%;*
>
> *ii) the shape of the urban area can lead to variation in energy demand of 20%;*
>
> *iii) density or clustering of trip destinations can bring about energy saving of 20%, mainly by facilitating public transport;*

iv) *dense or mixed-use zones, facilitating combined heat and power systems, can increase the efficiency of primary energy use by 100%;*

v) *layout and orientation of buildings can lead to energy savings of 12% through passive solar gain;*

vi) *sitting, landscaping, layout and materials can lead to energy savings of up to 5% through modifying microclimates" (Owens 1992).*

Owens suggested that land use patterns that reduce travel demand must include public transport and that high-density urban areas are most likely to facilitate public transport patronage. Therefore, proper consideration should be given to urban form that provides for high density areas adjacent to public transport routes.

> *"The options for future urban form based on policies of containment, higher densities in appropriate locations (such as long transport routes), avoidance of dormitory developments, mixed land uses, avoidance of employment and service locations that are car dependent, and encouragement of walking and cycling" (Owens, 1990)".*

Rickaby, Steadman, and Barrett (1991) focus more directly on land use as key elements in sustainability. They examined how fuel use and emissions in United Kingdom might change as a result of changes in the passenger transport system through experiments with land use and transport simulation models. The study provides some broad indications of the scale of reduction in energy use and carbon dioxide emissions which might in theory be brought about by changes in transport patterns.

They began with the empirical analysis of land use and transport patterns in a representative sample of twenty English towns with populations of between 50,000 and 150,000. They updated land use maps for each selected town with the help of information provided by the local planning authority,

and digitised land use data from the maps. Measurements were also made of the patterns of roads and streets in each town. The land use data was then processed using a Geographic Information System (GIS) in order to obtain a breakdown of land uses according to a standard pattern of zones which was applied to each town. This permitted the construction of a representative or an idealised *"archetypal town"*, consisting of a pattern of land uses and roading network.

The second stage of the research was a study of the local authorities planning documents for each of the sample towns, and a survey of the planning literature. The aim was to establish the likely ways in which the sample towns might develop, or be under pressure to develop, during the next twenty years. The most evident trend was the pressure being experienced by all the towns, and particularly those in the south of England to accommodate new private housing and large peripheral retail developments.

This led to the question of how to absorb new private housing in the study towns to improve the overall energy-efficiency of those towns. In order to answer this question, five modified versions of the archetypal town were devised. These included three versions in which new development was contained within the original urban area, and two versions in which it was directed into areas of peripheral expansion. The containment option directed development either into existing sub-centers or into new development corridors along existing main routes. In the peripheral expansion options, development was directed either into large low density areas between the original continuously developed urban area and the outer ring road, or into smaller areas where densities were chosen to be suitable for the provision of Combined Heat and Power (CHP).

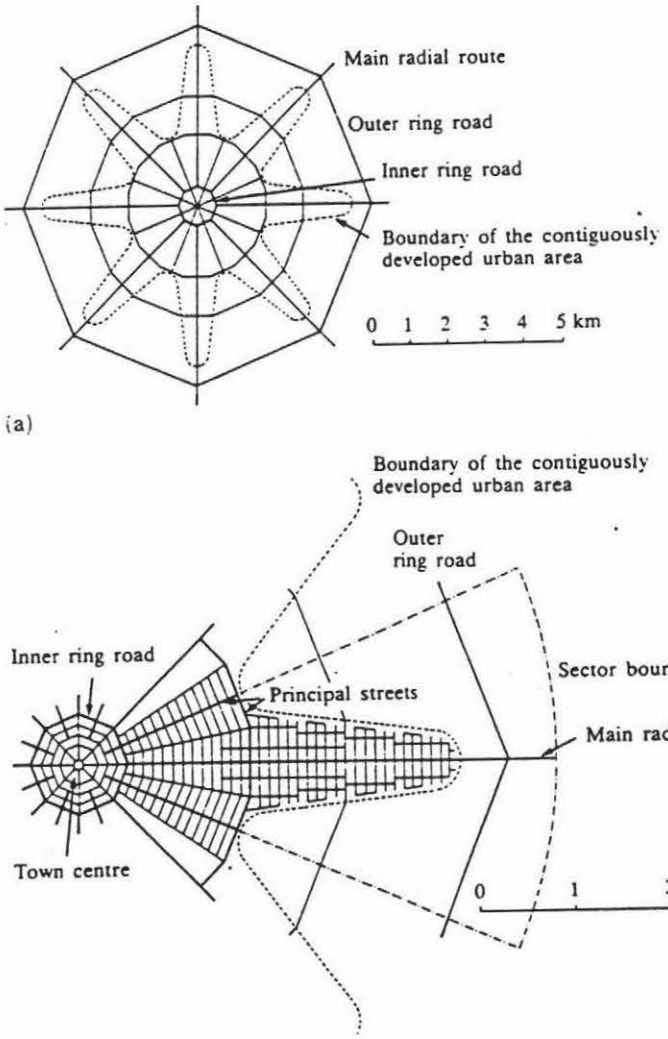
Figure 3.2 is a representation of an idealised 'archetypal town', consisting of a pattern of land uses and a road network which embody average or typical values for various characteristics of the pattern of development in the sample towns.

Figure 3.3 shows five modified versions of the archetypal town. Option (a) is a containment option in which new development is concentrated into four of the eight existing suburban centers. Option (b) is a containment option in which new development is along four of the main radial roads leading

out of the town center. Option (c) is a combination of (a) and (b), in which new development is concentrated into four of the eight existing subcenters and along the radial routes which connects them to town centers. Option (d) is peripheral expansion option in which it is assumed that all the land between the boundary of the developed urban area and the outer ring road is made available for new development. Option (e) is new medium-density development areas between routes with increased road and public transport capacities (Rickaby and Steadman, 1991).

Figure 3.2

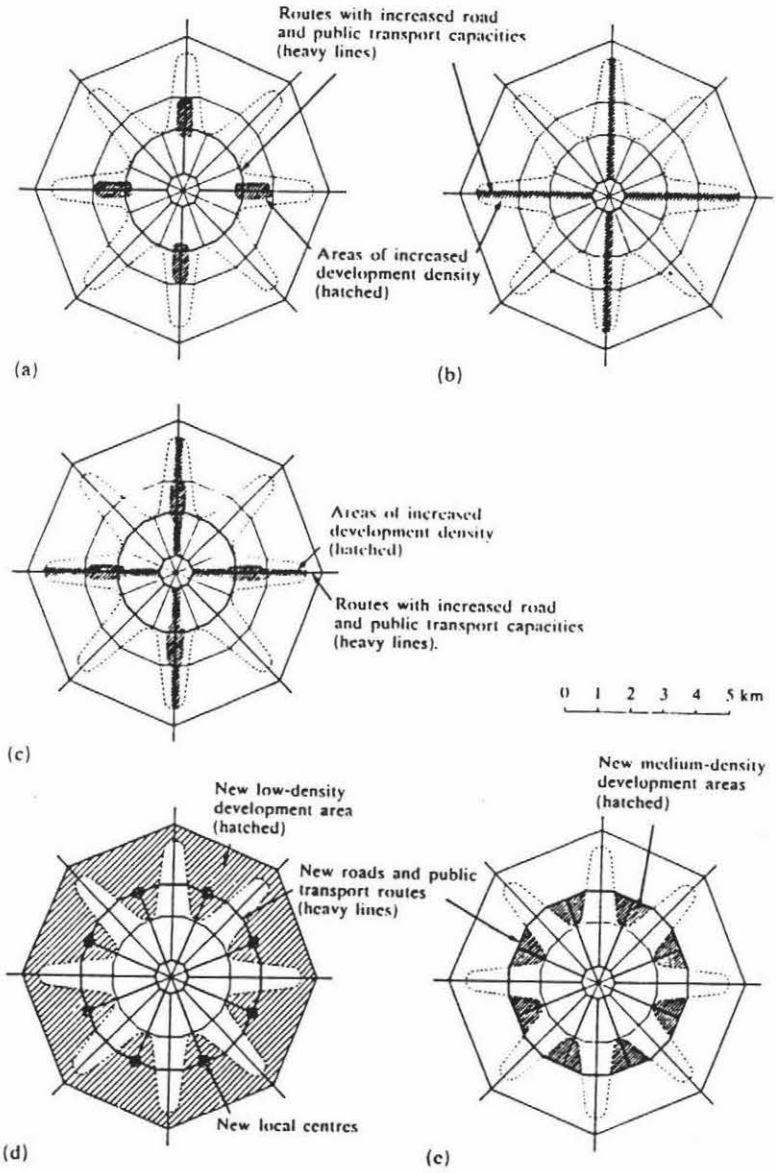
Ideal Archetypal Town



Source: Rickaby, Steadman, Barret (1991)

Figure 3.3

Five Modified Versions of Archetypal Town



Source: Rickaby, Steadman, Barret (1991)

3.6 URBAN FORM FOR URBAN SUSTAINABILITY

Archetypal, baroque layout, star, or mixtures of rectangular and linear urban forms are the most sustainable layout plans. The ideal sustainable layout plan would comprise of one super block between 10,000 and 40,000 population having medium density which is a suitable size for pedestrian or bicycle use. Each block will be an integration of housing, commercial, cultural and employment activities. The number of jobs and other needs being equivalent to the peoples' needs in one block..

In the New Zealand case, it is difficult to achieve density between 20-40 persons per hectare, in all urban areas, but not impossible. However, it is possible to get a medium density of population which provides a basis for socially and environmentally sustainable settlement patterns. City blocks between 10,000 and 40,000 population seem the best physical dimension for a sustainable city because many services can be provided without increasing cost and the density of population. These clusters of city blocks can create urban settlements starting from 10,000 to 250,000 or more. This city size emerged as the best option, because they could plan and implement environmentally friendly infrastructure and also encourage alternative means of transport .

The following criteria extracted from the preceding review are proposed as a basis for achieving sustainable urban form:

- Encouraging rectangular in conjunction with star city layout;
- Encouraging heterogenous land use patterns;
- Development of areas within major arterial routes diverging from the city centre;
- Encouraging residential densities of more than 28 persons per hectare and the suburban density of 6-10 persons per hectare.
- Reducing infrastructure costs and operating costs with proper designs of physical infrastructure and open up the opportunity for a level of social interaction that transcends the isolation of low density suburbs;

- Adopting information-efficient and energy-efficient criteria as proposed in the previous sections through building location and orientation, passive solar heating and cooling, delighting and shared use of capital-intensive facilities;
- Balancing population and job opportunities within each city block;
- Developing a medium density city block having a population between 10,000 and 40,000;
- Limiting urban settlements up to 250,000 people.

3.7 CONCLUSION

There are number of different, loose definitions of sustainability which are open to debate within and between different disciplines. Nijkamp has defined sustainability in a regional development sense. Owens has discussed the impossibility of urban sustainable development, given the flows of resources and pollution and waste across boundaries. Rickaby, Steadman, and Barrett (1991) focus more directly on land use as they believe that land use arrangement is a key element in sustainability.

In considering urban form, it is not advisable to make policies which go against the well-established trends. It is difficult simply to stop the suburban growth trend which has been a dominant urban force since 1945 in most western countries. A better approach may be one that achieves a balance between compactness and decentralisation, having regard to environmental and other objectives. This would appear to correspond to decentralised concentration as a basis for settlement planning, a form of urban development proposed in different forms by Owens; Orrskog and Snickars; Breheny; and Van der Valk.

CHAPTER 4
LAND USE, TRANSPORT AND URBAN SUSTAINABILITY

4.1 DESIGNS FOR SUSTAINABILITY: URBAN FORM AND SUSTAINABILITY

Sustainability is defined in a number of ways, but the main emphasis is on meeting the needs of the present generation without compromising the needs of those of future generations. Even given this broad conceptualisation, sustainability is a multi-faceted concept. It can refer to the economic, technological, social, cultural and political impact of settlement, all of which must be accommodated and planned for, effective and efficient operation of cities. At the same time, operational criteria are needed to ensure that the natural environment at local, regional and global scales can be conserved and protected for future generations without compromising the built environment.

In transport terms, sustainability is mainly concerned with the consumption of finite resources and the production of harmful or wasteful emissions. Therefore, transport systems are central to urban sustainability. It is through their impaired effect on the transport demands and the efficiency of transport systems that different urban forms, have the greatest impact on sustainability. When a city grows physically, there is an increase in average commuting times especially as related activities, such as employment and housing, become more distant, and as the functional differences between suburbs and the central city increase. Land use planning, transport and urban design jointly play a vital role in promoting sustainability, as they provide the framework for future development. In the previous chapters urban consolidation and decentralised concentration were considered to be the urban form most likely to support sustainable cities. This chapter deals with the operation and dynamics of cities, including reurbanisation, reorientation of the transport system and inner city redevelopment programs, through which planners might work to achieve sustainability within the built environment.

4.2 THE PRIVATE VERSUS PUBLIC VEHICLE USE

Another contributing factor towards urban expansion is increasing wealth which has allowed people to live in more spacious surroundings and led to more dispersed patterns of travel. One interesting feature in the recent development of sprawling cities of USA, Australia and New Zealand has been the rise of strong suburban centres, which have themselves become magnets for decentralising jobs. It is now widely argued that within large cities it is appropriate to foster the development of a number of strong sub-centres within the city (Beaumont and Keys 1982, Brotchie 1992), concentrating traffic flows sufficiently to encourage public transport.

In reality, the increasing sprawl of the city and the functional separation of activities have added to the demand for private motor cars and tend to reduce the viability of public transport. The problems associated with high urban car usage calls for altering the balance of passenger movement away from private and towards public transport. The high usage of private transport has resulted in uneven urban expansion and spatial polarisation of economic activity. The world of high transport use in industrialised countries fosters motorway networks which serve only certain routes and high speed rail links are even more rare, leading to polarisation of urban and economic activities.

> *"Thus two sorts of areas are taking shape: the first, with good services where these rapid networks intersect, attract the bulk of the most go-ahead forms of activity and are usually located in the vicinity of major urban centres; and the second, surrounding these pockets of high development, areas which have been, as it were, pushed aside, left out of the economic competition between regions and merely kept alive by a few traditional productive activities like agriculture" (Bonnafous, 1988).*

The second risk associated with high usage of private transport and speed is network saturation as a result of increased mobility with economic growth, the concentration of traffic on fast networks and expansion of international trade. Very heavy investment is required to overcome these problems as it involves major public investment. It is important to know whether an extra

motorway route should be built or whether better use can be made of existing infrastructure (Bonnafous, 1988).

According to the Friends of Earth (1991):

> *"a balanced national transport policy and development programme is needed, based on the promotion of walking, cycling and mass transit, the reduction of the total road capacity for private vehicles, particularly within cities, and enhanced safety for all road-users. Higher technical standards of fuel economy and emission control are also required to reduce the environmental impact of the remaining vehicles." (Elkin & McLaren, 1991).*

Although a general consensus has been established about the need for sustainable development and sustainable fuel use, there is a need to address questions such as 'How do we measure whether a society is sustainable?' and 'Is the country more sustainable now, than it was in the 1980's?'. There is a need for some sort of quantitative measure or ' *criteria of sustainability'* for future land use and transport planning.

4.3 REURBANISATION APPROACH

The reurbanisation concept has been developed in Europe and supported by Berg (1981), Berg, Burns and Klaassen (1987). This strategy has proved to be a useful solution for conserving natural and physical resources and as a means of attracting people to downtown areas that have been depopulated. According to Brian Berry, reurbanization could bring about the following changes (summarised by Edner and Arrington, 1985):

i) The conversion to higher density uses within the corridor;

ii) A shift to multiple family development into the LRT corridor;

iii) A reduction in the growth rate outside the corridor;

iv) The need for significantly improved urban services within the corridor;

v) A general positive impact on property values;

vi) *A total reduction in energy utilisation from development in an energy-efficient area;*

vii) *A reduction in automobile use and ownership;*

viii) *A reduction in public costs associated with both development and environmental pollution.*

urban population begins to grow and by its very growth it attracts people from the rounding countryside, setting a downward migration, often on a large scale, in tion. It is mainly the abundance of workplaces in the city that attracts migrants for, moving to town, they can greatly improve their living conditions. There comes a vement, however, when rising incomes and increased car density induce a shift of dential location towards suburban areas, basically the very areas from which ,rants used to come. Things keep shifting and changing; at a certain moment the ; city becomes so crowded with workplaces that their very density impedes the per functioning of the economic activities they represent; from then on an exodus of kplaces from the city begins, following that of residents. Part of the activities locate newly built industrial estates, others settle in recently constructed residential areas. the last phase of the cycle both workplace and inhabitants are leaving the lomeration(Berg, Burns and Klaassen, 1987).

rbanization involves not only providing better use of land by controlling urban sprawl but also ourages development which is less automobile dependent. Berg , Burns and Klaassen (1987), cribe the reurbanisation process in terms of spatial cycles and characterised it as follows:

> *This cyclic process is first manifest in the old historical city (within the medieval defence ramparts); in the stage of suburbanisation it can be recognised in the city core, and in the disurbanisation stage, has spread across the whole agglomeration. It is at this stage that most West European agglomerations have now arrived; the stage where they suffer the loss of population and workplace" (Berg, Burns and Klaassen, 1987).*

The authors also describe reurbanisation in the following way:

> *The process thus set is one of once more turning degenerated urban patches into city quarters with living cores, fulfilling a real economic, social and cultural function, a process of reurbanisation. Its ultimate fascinating objective is the revival of the old core cities, fascinating to many individuals who have learnt in hard practice that living near to nature means mowing the lawn every week, driving downtown in long queues every morning and driving out to town in long queues in the evening; that a suburban home means buying a second car for their wives so that they may flee the periphery, etc* (Berg, Burns and Klaassen, 1987).

Reurbanisation alone can hardly solve the problem of depopulation of traditional downtown and the consequent increase in wasteful use of the natural and physical resources. Newman and Kenworthy (1989) combined reurbanisation with five physical planning factors which they identified as controlling automobile dependence (Box 4.1).

The authors argue that there are a number of policies other than reurbanisation which can simultaneously reduce problems associated with automobile dependence. Reurbanisation, which 'addresses the question of more intensive and centralised land use' is just one of the alternatives. It incorporates a land use pattern which should reinforce each of the five factors identified by Newman & Kenworthy as the key determinants of gasoline in 32 cities around the world.

The summary of the stages in urban development to highlight the term reurbanisation and its major policy components and implications for transport and other socio-economic and environmental factors is shown in Box 4.2. Box 4.3 shows conclusion derived by Newman and Kenworthy. Together, these items demonstrate the overlap between transport and land use policies. The combination of these effects assist in the resolution of the broad urban problems which beset automobile-dependent cities.

For practical planning purposes, if a region or corridor were to be built with a minimum urban density of 20 and preferably 30 to 40 people per hectare, then this should lead to more use of public

transport, walking and cycling. The reasons for this include the combination of shorter distances, a more viable concentration for public transport and greater congestion for cars. However, it should also be added that each of these factors can be abused by inappropriate planning, so that transport patterns can be pushed more toward cars despite high densities. Inappropriate planning policies could include:

i) placing higher density housing development a long way from all other major urban activity (not close to bus terminal/railway station, employment and other activities);

ii) not making housing stock available for all income groups;

iii) forcing the development into more of an auto-mode by large adjacent roads and by making available excessive parking.

Medium to high density urban development would provide a choice of lifestyle for those residents who have no access to cars or person with disabilities. It may also suit certain people eg. older people who are not willing to use a car anymore and single people who only want accessibility.

Box 4.1

FIVE PHYSICAL PLANNING FACTORS

i) *Inventory of Land use*

Land uses are denoted by:

a) Urban density (residential population per ha of urbanised land).
b) Employment density (jobs per ha of urbanised land).
c) Inner area density (person per ha of urbanised land).
d) Inner area employment density (jobs per ha of urbanised land).
e) Outer area density (persons per ha of urbanised land).
f) Outer area employment density (jobs per ha of urbanised land).

ii) *Inventory of transport infrastructure and mode of Transport*

More infrastructure to non-automobile modes are denoted by:

a) Per capita passenger kms in cars.
b) Per capita passenger kms in public transport.
c) Proportion of total passengers kms in public transport.
d) Proportion of workers using public transport for the journey to work.
e) Proportion of workers using private transport for the journey to work.
f) Proportion of workers walking and bicycling for the journey to work.
g) Total vehicles per 1000 people.
h) Cars per 1000 people.

iii) *Road capacity and parking standards*

More restraint on high speed traffic flows are denoted by:

a) Length of road per person.
b) Parking spaces per 1000 central area jobs.
c) Vehicles per km of road.
d) Car kms per km of road.

iv) *Inner Business Zone*

More centralised land uses are denoted by:

a) CBD density.
b) Proportion of metropolitan population residing in the CBD.
c) Proportion of metropolitan employment located in the CBD.

v) *Public Transport*

Better performance of public transport is denoted by:

a) Vehicle kms of public transport service per person.
b) Passengers trips per person.
c) Passengers trips per vehicles km of service.
d) Average speed of total public transport system.
e) Energy use per passengers km.

Source: Newman and Kenworth 1989

Box 4.2

Policy Component of Reurbanisation

• **More intensive land use.**

Reurbanisation by definition intensifies land use in inner, outer and central city areas by techniques such as infill, redevelopment, dual occupancy housing, air rights over transit lines, incentives for central city housing....

• **More orientation in transport infrastructure to non-automobile modes.**

This is the major thrust of the next policy area to be discussed but reurbanisation provides the opportunity for non-automobile modes to flourish. The provision of infrastructure by itself will not be successful eg cycle paths can help promote bicycle use but in very low density cities distances are just too far for any significant bicycle use. Thus reurbanisation is the land use component which will help to make public transport, bicycling and walking feasible options . It is necessary to provide the infrastructure but it is generally not sufficient unless accompanied by the land use changes suggested by reurbanisation.

• **More restraint on high speed traffic flows.**

This again relates primarily to the next policy area but it can be seen that where you have low density scattered land use then high speed roads appear more necessary to ensure economic transport linkages; on the other hand if land use is intensified then not only is there less need for the high speed road alternative but there is less possibility for it to be built through more developed areas. Thus reurbanisation works against the need and the possibility of high speed road alternatives and enables a more balanced transport system to be achieved.

• **More centralised land use.**

Reurbanisation as outlined highlights the role of the city centre. It also suggests that strong sub-centres (as in Toronto) can be developed to intensify land use in inner and middle suburbs. To reurbanise is to highlight the centre and sub-centres rather than scattered land uses which can only be serviced by the automobile.

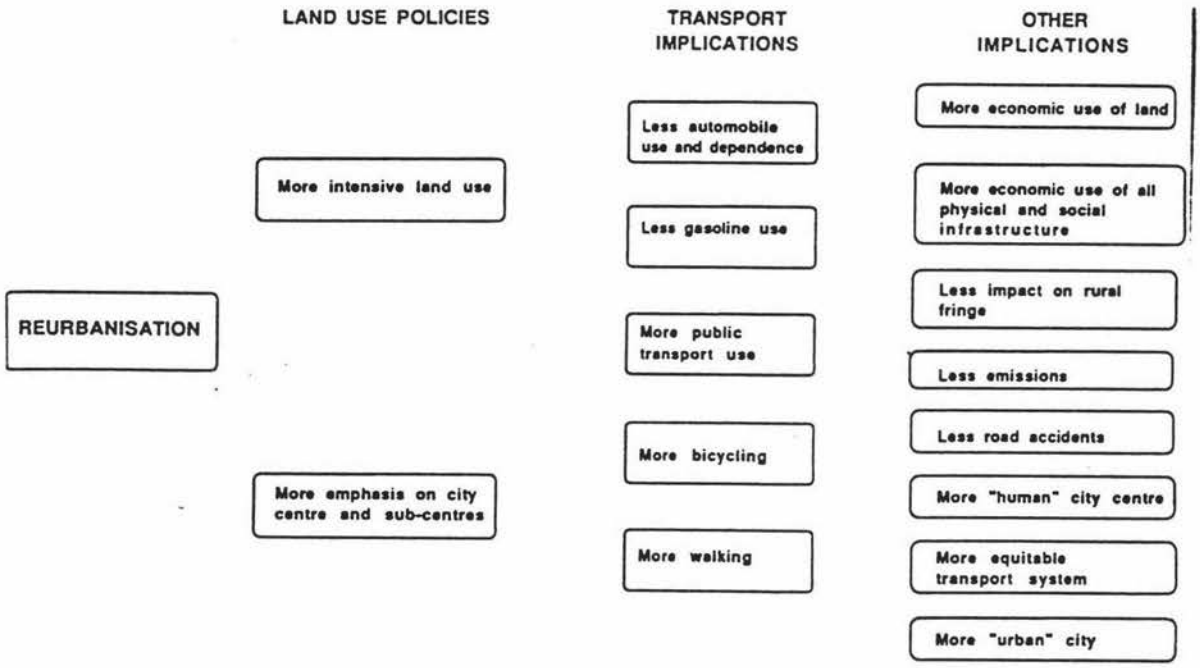
• **Better performing public transport.**

Reurbanisation as already mentioned provides the opportunity for public transport to perform better. If the land use is not conducive to public transport then all the transit management techniques and customer incentives in the world can do little more than start a process which induces land use change.

Source: Newman & Kenworthy (1989)

Box 4.3

Major Element In Reurbanisation Policy Showing Overlap Between Land Use and Transport Policies



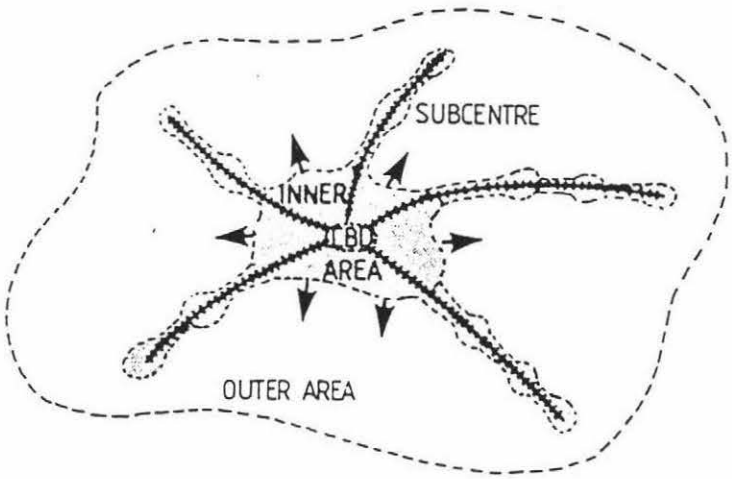
Source: Newman & Kenworthy (1989)

Like Rickaby, Steadman, and Barrett (1991), Newman and Kenworthy (1989) evolve policy directions as a result of empirical work to demonstrate sustainable urban form and transport network. They support the findings of urban designers who favoured planning priority for middle suburbs. They use information from 32 cities to conceptualise the form of reurbanisation likely to be most effective in reducing fuel use (Figure 4.2). Their synthesis highlights the importance of inner area redevelopment for the highly auto-oriented cities. It reflects the potential for reurbanisation as low densities give rise to significant potential for infill development. Their vision of sustainability would encourage intense mixed use development of vacant or under utilised land and redevelopment of existing inappropriate land uses.

One planning priority for urban areas in USA, UK, Australia and New Zealand cities should be reurbanisation at higher densities. The type of land use in the old inner suburbs needs to be readjusted as shown in Figure 4.2. This will require a full range of reurbanisation policies, including in-fill development, redevelopment of industrial and warehouse sites, resubdivision, declining density percentage, intense mixed use developments, air-rights development over rapid transit routes and conversion of un-needed road reserves.

Figure 4.1

Conceptual Plan For Reurbanisation



Source: Newman & Kenworthy (1989)

.4 TRANSPORT REORIENTATION APPROACH

he reorientation of transport priorities mainly addresses the question of transport infrastructure, affic restraint and public transport. Newman and Kenworthy (1989) argued that the policy of orientation of transport priorities offers an integrated pattern which improves the five physical ctors outlined above. Each city has a distinct transport pattern and energy consumption ehaviour which reflects its particular urban form. Transport patterns reflect a range of rcumstances: parking supply in the central city; the extent of the road network; vehicle ownership the city; total kilometres of travel by vehicles; the average speed of the traffic system; the modes ed for various trips (journey to work); average trip lengths for various purposes; and fuel nsumption patterns.

ox 4.4 shows how the reorientation of transport priorities has a range of other urban policy plications. Box 4.5 shows the five factors envisaged by Newman and Kenworthy and stresses w the transport and land use policies are so closely linked.

ie central theme of reorientation of transport is based on planned congestion which can be used help a city become less automobile dependent. Planned congestion can help a city to progress wards lower car dependency and lower energy use through a better balance between public nsport, walking and cycling. This has to be followed by a change of priorities in transportation licy towards public transport.

iis approach may be useful for low to medium density New Zealand cities with regard to major w roads. Planned congestion could offer an opportunity to help contain the outward growth of ies, develop more efficient, concentrated nodes of urban activity, shorter travel distances, give ority to public transport and fundamentally lower automobile dependence and transport energy e of our cities.

Box 4.4

Policy Component of Reorientation Transport Priorities

- **More intensive land use.**

A rail oriented transit system offers enormous potential for intensification of land use as it can deliver large numbers of people within walking distance of stations. Pedestrian and bicycle facilities supplement this intensification process. The shift from high speed road services will have a large impact on containing land use rather than the urban sprawl associated with freeway extensions.

- **More orientation in transport infrastructure to non-automobile modes.**

This is the major thrust of the re-orientation policy as outlined for parking, roads, transit and infrastructure for other non-auto modes.

- **More restraint on high speed traffic flows.**

The re-orientation policy accepts this directly and redirects funding from high speed roads into traffic management and infrastructure for other non-auto modes. It also uses the land which would have been set aside for such road projects to intensify urban land uses thus encouraging other non-automobile modes.

- **More centralised land use.**

The provision of rapid transit to central city and sub-centres will centralise land use. Especially if this is also done in conjunction with a policy to reduce parking and increase populations in central areas.

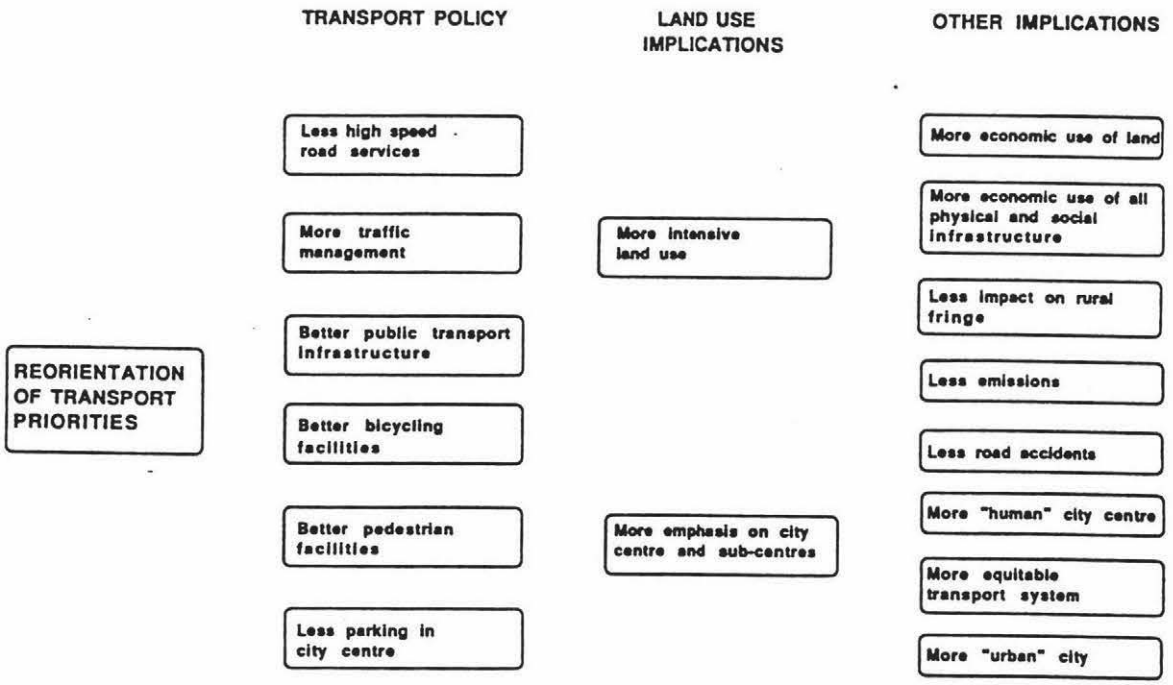
- **Better performing public transport.**

The re-orientation policy will undoubtedly improve the performance of public transport through its combination of improved infrastructure, less provision for automobiles and better land use to enhance the use of public transport.

Source: Newman & Kenworthy (1989)

Box 4.5

Major Element In Reorientation Of Transport Priorities: Major Policy Components For Land Use Planning, Socio-Economic and Environmental Factors



Source: Newman & Kenworthy (1989)

4.5 IMPLICATIONS OF URBAN FORM, DENSITY AND ENERGY CONSUMPTION

Traditionally, planners aim to support economic development to secure better standards of living and protect and improve the environment. Their biggest contribution in increasingly urban world would be to define urban design patterns which minimise the need for travel, thereby reducing energy consumption and pollution.

Newman and Kenworthy (1989) argued in their survey of energy use in cities throughout the world that population density, job density and city-center dominance influenced petroleum use. They demonstrated a strong increase in petroleum consumption when population density falls below 29 persons per hectare. They argued for cities with strong centres and intensively used suburbs, which can sustain quality public transport and more walking and cycling.

Newman(1992) widened the analysis, however, when he compared Australian cities with European cities in terms of safety, equity, and the environmental effects of urban transport and drew attention to the trade-offs involved. He suggested that by reducing private motoring, only a small contribution could be made in fuel saving. He also questioned whether increasing population densities is the way to achieve this. He argued that sprawling Australian cities are not unsustainable environmentally, nor are they economically inefficient, inequitable, or unsociable. He supported his arguments regarding environment, economic and equity issues by comparing Australian cities with cities in Japan and Europe. He argued that Australian cities average about a quarter of the population density of European cities and per head of population they have:

i) *about twice the kilometres of private motoring;*

ii) *about four times the length of roads;*

iii) *three quarters of the public transport route length, but only half of the passenger kilometres and much less than half the numbers of passenger journeys;*

iv) *about a quarter as many journeys by foot or bike (Newman 1992).*

Newman pointed out that Australians make 12 per cent of their journeys by foot, bike and public transport, compared to 46 per cent in Europe. Although these figures suggest that the system is very expensive and inefficient, according to Newman, it is superior in terms of urban space per person (the quarter acre backyard), involving only 18 per cent more travel time and 64 per cent more travel mileage than Europe. The difference is that urban space in Australia is used for roads, parking, garden spaces, school play grounds, public parks and other recreation facilities.

Newman acknowledged that transportation in compact cities uses less fuel and emits less pollution. Transport uses 30 per cent of the total energy used in Australia, but only 3 per cent of national energy use could be saved by more urban public transport. He proposed that by limiting the size and power of vehicles and converting the cities to European density, 6 to 7 per cent of the total energy could be saved. But less than half of that would come from the higher density and some of the gain would be reduced by the energy cost of rebuilding the cities and servicing vertical development.

Supporting the claim by Castle's study (1990) which compared the wage price of household necessities in Sydney with the same basket purchased in Europe and Japanese cities, Newman argued that Australian cities are more efficient economically than their European and Japanese counterparts. Equity was also favoured by the high level of car ownership and access to recreational facilities in Australian cities compared to European and Japanese cities.

Newman perhaps did not give attention to the fact that by saving 6-7 per cent fossil fuel per annum, the country could conserve 100% energy after eighteen years, which would be sufficient for one year's consumption of a future generation. There are a number of other energy uses which could be controlled and conserved for equitable distribution among the future community members. Taken in conjunction with other measures, including more efficient building design and non-transport energy management in the city, the use of solar power as a primary or supplementary source of energy, a sufficient commuter contribution to major long-

term savings could be made to justify strong policy indicators for reurbanisation, and transport reforms.

There may well be structural constraints on achieving the implied savings, however, in his analysis of relationships between urban form, density and energy consumption, Sharp (1982) suggested that Melbourne would achieve 11% energy savings if density were increased three times. Small (1980) suggests that an energy-induced land use control that results in densities of 15 units per acre compared with US average 5 units per acre would reduce car usage for work by only 1.4% after six years (Banister 1992).

Rickaby (1987, 1991) compared six different energy-efficient city-regional settlement patterns against three economic growth scenarios based on the British experience. He outlined six patterns:

i) existing settlement pattern;

ii) concentrated nucleated with density of 33.9 to 45.5 persons/ha;

iii) concentrated linear with density of 16.96 person/ha;

iv) dispersed nucleated (satellite towns) with primary density of 33.9 person/ha, and secondary density of 28.9 person/ha;

v) dispersed linear with density of 10.96 person/ha

vi) dispersed nucleated (villages) with density of 28.9 person/ha.

The densities per hectare in the settlement pattern proposed by Rickaby (1991) except in options 1 and 6 are very close to the critical density of 29 person/ha identified by Newman and Kenworth (1989).

Although energy conservation does not appear to have high priority in contemporary British planning, the need to absorb new private housing in many towns does raise the question of how to do so in a way which improves energy-efficiency of those towns. In order to examine the energy efficiency of various strategies with which new development might be accommodated in the sample town, a number of modified

versions of the archetypal town were constructed. The modified versions all had the same overall population as the original, but in each case households, employment and services were assumed to have relocated over a period of twenty years in response to development-control policies. It was also assumed that average household size decreased (from 2.5 persons to 2.1 persons per household), and that employment was maintained at an average of one job per household, resulting in increases of approximately 20% in the number of households, the number of jobs and the amount of floor space.

Rickaby concluded that the existing configuration is efficient in terms of accessibility and cost. Settlement patterns based on concentrated nucleated settlements with densities of 33.9 to 45.5 persons/ha and dispersed nucleated (villages) with density of 28.9 persons/ha show both fuel savings and increased transport benefits. He concluded that modest concentration of development into local centres within the hinterland of the existing city both saves fuel in transport and improves accessibility (Ricaby, 1987).

Banister (1992) in his analysis of the UK National Travel Survey data suggests that per capita fuel consumption from travel is highest in rural areas, and lowest in large, high density cities. He reviewed the correlation between urban energy consumption rates with densities and undertook hypothetical modelling of urban form and energy consumption. He concluded that the smallest rural settlements are the least energy efficient

Breheny (1991), in his paper 'The Contradictions of the Compact City: A Review' also suggested that higher density cities around the world tend to exhibit lower fuel-consumption rates. The review work on energy use, transport and settlement patterns by Banister suggested *'decentralised concentration'* - that is the promotion of urban and suburban cores-might be a fuel-efficient urban form.

He concluded:

i) *single objectives in the pursuit of greater energy-efficient will be misguided;*

ii) *a balance should be struck between transport and other social, economic, and environmental objectives;*

iii) *some degree of urban containment is required;*

iv) *new residential developments should be related to jobs and services;*

v) *satellite development close to, and integrated with, existing urban areas is likely to be energy-efficient.*

ban sustainability requires us to protect and conserve fossil fuel, but also encourages us protect and conserve our natural and physical resources in order that our own human vironments, which depend on air, water, ecosystems and the biosphere can function operly now and in the future. Urban development, by contrast means sustaining the frastructure of a city, its form, population, economic base, and even its resource nsumption. To achieve both sets of objectives, it is important to see the possibility of aking policies for efficient use of energy resources and explicit goals of land-use velopment plan. Sustainability may be achieved by pursuing policies of decentralised ncentration, reurbanisation, reorientation of transport systems, urban containment, and lective intensification and mixing of land uses at a scale which provides reasonable oices of jobs and services.

.6 KEY CRITERIA OF SUSTAINABLE TRANSPORT AND LAND USE PLANNING

here is a need to establish polices and criteria for land use and transport keeping in mind ie socio-economic values and behaviour of people who will have to conform with these riteria. Important factors which need to be addressed when designing criteria for ustainability include community need and preferences, new approaches to traffic restraint, ark and ride opportunities, ride sharing and traffic calming.

he challenge is to have strategies which improve cities as places to live, work and play, hrough planning and related policies to influence urban size, shape, density and form.

sport strategies are also important in this list with improvements required to provide nunity access by private or public transport to facilities within and around the urban

preceding sections suggest that the key parameters of sustainable transport and land use ning are containment and selective intensification, with more concentrated development around ions and corridors that can be connected efficiently by public and private transport. banisation and high density mixed land use at selected areas within the city and reorientation of port priorities are measures to curb the waste of fossil fuel and land resources. Policy elines and criteria associated with sustainability derived from the preceding sections are osed below:

i) Land use, Urban Form and Density

Land use criteria calls for more intensive use by developing land currently under utilised. Urban form is also influenced by conversion of low density residential and commercial areas to high density along and in major corridors, and encouragement of mixed use and high levels of occupancy. This density change in urban areas can only be obtained if a mass land and transport changes occur in the CBD and in the new sub-centers or nodal points. The policy may be achieved through selective intensification of land use at certain nodal points.

The land use, urban form and density measures also emphasise more centralised land use, by favouring sub-centers at medium to high density nodes of activity within the medium density suburbs, making cycling and walking more viable modes of transport. Social and economic conditions are also deciding factors about the future land use and urban form of the cities. Increasing wealth, brought about changes in the work patterns and lifestyles, which have led to greater demands for personal mobility, more time to travel and more dispersed travel patterns.

The following sustainability policies are desired for future land use, urban form and population density:

1. Moving towards more intensive land uses by creating a compact city, (by developing an inventory of all land uses which are unutilised or under utilised in the central, inner or outer area) by way of in-fill development.

2. Converting residential areas to high density along and within the major corridors and encouragement of mixed use and dual occupancy housing.

3. Shifting of multi-family dwelling developments into transit corridors.

4. Converting under-utilised land to alternate uses.

5. Encouraging more centralised land use by developing sub-centers at medium to high density nodes of activity within the medium density suburbs making walking and cycling more viable.

6. Giving incentives to motivate the developers to locate their big development projects in the CBD or nodal points to achieve urban containment.

7. Controlling new development in urban areas by balancing jobs and population required to support these developments.

8. Developing new areas by integrating them to the existing urban areas for energy conservation and efficiency.

ii) <u>Environment and Transport Viability</u>

Modal transfers are overwhelmingly from public transport and other modes to car travel. This trend is the underlying factor which influences natural resources, and

causes congestion and CO2 emissions. The mutually reinforcing trends of increasing car ownership and widespread dispersal of population and employment are evident in most cities. Population seems to be decentralising faster than employment and, as a result, there has been an increase in trip lengths. Given the high predictions for the future growth of car ownership and traffic, the concept of sustainability is unlikely to be realised through the more popular policies (OECD, 1995).

One policy option is to give a subsidy to public transport and encourage alternative modes of transport. Other policies are to improve traffic management systems, develop and provide safe and efficient public transport systems, and encourage cycling and walking.

The following policies are proposed to encourage more sustainable transport systems:

1. Encouraging alternative modes and means of transport such as ride sharing and park and ride.
2. Subsidising public transport to make a shift possible from car use to public transport.
3. Developing better traffic management, safe and efficient public transport systems, bicycle routes and pedestrian connections in the city center and sub-centers.
4. Reducing energy utilisation by focussing development on energy efficient areas or sub-centers/nodal points.
5. Setting policies for mass transit programs through high density corridors.
6. Reorientation of transport priorities to the main corridors and regulating traffic volumes to conserve fossil fuels.
7. Developing and promoting high occupancy transport modes in congested corridors.
8. Reducing the effects of transport systems on the environment.
9. Monitoring energy use and emissions related to rise in automobile use in most cities and difficulties faced in absorbing physically, the demand placed on them.

iii) Behavioural Changes

To adopt sustainable policies there is a great need for behavioural changes to reduce car dependence. This could be by discouraging cars from entering the city center, by total bans, bans and permits or permits for business use of cars. Total bans on entry into or use of controlled entry into the central business district, or limiting entry to certain hours of the day for environmental and traffic reasons are all possible policies. Putting heavy tolls at some cordon points and putting tolls at major bridges may also reduce the cross-commuting problems.

Another policy measure which may discourage cars from entering the city center is the use of heavy parking fees. This measure could help reduce vehicle dependence. Pricing is also suggested so that licenses in congested areas should be taxed at a higher rate than those licensed elsewhere. Another way is to regulate the use of vehicles in congested areas by means of permits. Charging different rates of motor tax, according to area of use and direct pricing is also proposed. However, all of these measures are expensive to implement, difficult to enforce and may simply disturb behaviour without reducing vehicle dependence.

It is important to examine the possible effects, advantages and limitations of various measures such as: traffic restraint; car sharing and car pooling and urban freight distribution. The concern is to assess whether and to what extent these policies:

a) could be enforced;
b) would avoid introducing restrictions that were not, in fact, essential to improving traffic conditions; and
c) would avoid other undesirable consequences, such as the replacement of one component of traffic by another, giving rise to just as much congestion.

It is a well known that control by pricing is inherently easier to implement than control by regulation, and greatly reduces problems created by claims for exemption.

The following are sustainable policies for behavioural changes:

1. Controlling car dependence by discouraging cars entering the city center, by heavy tolls at entry points or major bridges within urban areas.
2. Discourage car use and limit cars entering the city center by increasing parking charges within the Central Business District.
3. Conversion of existing under utilised parking lots and land located in the Central Business Districts of major urban areas into a more productive land uses.
4. Regulating vehicle number and use

iv) Energy Efficiency

Energy efficiency is not only achieved through better urban form and density control but also through other means of achieving energy efficiency, such as use of small vehicles and the possibility of using bio-gas as an alternative energy source to fossil fuel. Use of small motor vehicles which are energy efficient needs promotion at national and international levels. This policy can be implemented by involving vehicle manufacturers in the debate of sustainability and convincing them to shift production towards manufacturing small engine vehicles.

Control over energy consumption can also be achieved by putting a limit on the production of vehicles to certain fixed numbers which is proportionate to the population increase. Another way is to put limits on the number of vehicles allowed to be registered in particular districts on the basis of population growth and capacity to handle automobiles on existing or proposed roading networks.

Ideally, there are five factors which contribute to the reduction of fuel use and dependency in conventional transportation systems. Increasing the efficiency of cars is one of the ways to reduce fuel usage and dependency as they dominate passenger transport. Those five factors are:

1. Vehicle efficiency/engine design
2. Driving practices/speed
3. Fuel substitution
4. Public transport use
5. Reduction in travel demand

Fuel efficiency can be achieved through technological advances in engine design, reduced engine size, and better maintenance. The fuel efficiency of new cars increased between 1979 and 1985 in New Zealand but with declining oil prices towards the end of the 1980s, engine size and fuel efficiency has remained static or declined.

More efficient driving practices including speed moderation, is another way to reduce fuel demand. Optimum speeds for cars are around 60 kph in urban areas. Urban areas and junction layouts are also of importance to fuel efficiency. Savings can be achieved through reducing junction delays and raising the urban area speed limit to 60 kph. Carbon dioxide emissions are also lowest per vehicle kilometre at around 60 kph.

Another way of reducing fuel uses is by shifting to indigenous fuel such as liquid petroleum gas (LPG) and compressed natural gas (CNG). The trend towards using LPG or CNG is decreasing despite favourable price and fuel efficiency. One probable reason is the small proportion of fuel costs in overall lifetime costs and the inconvenience associated with CNG and LPG technology.

Shared trips and use of public transport offers the opportunity to improve fuel efficiency. Inducing a transfer to public transport is unlikely to be easy in New Zealand. A demand study of a short distance (5kms.) rail corridor in Wellington suggested that doubling of petrol prices from $1 to $2 per litre would cause a 4.9% increase in rail trips and reduction in car trips of 3.8%. If the increase in petrol price was via a rise in tax, with some or all of the tax revenue used to halve rail fares, a 6.3% reduction in car trips and a 20.1% rise in

rail trips was predicted. On its own, halving of rail fares would reduce car trips by 1.8% and increase rail trips by 12.6% (Douglas & Nuttall, 1992).

The last factor that could contribute energy saving is a reduction in travel demand. There has been an annual increase of 2.3 % in petrol consumption in New Zealand between 1968 and 1990. Similarly car ownership has also risen quite rapidly in New Zealand compared with other countries in the world.

The policies related to energy efficiency are:

1. Limiting the number of vehicles allowed to be registered in a particular district/city.
2. Limiting the urban area speed to 60 kph.
3. Increasing the price of petrol via a rise in tax.
4. Encouraging motor manufacturing companies to design oil efficient motor vehicles using the current research on factors, which contribute to the reduction of fuel use.

v) Urban Design Parameter

A sustainable built environment is the one which provides urban designs that are environmentally friendly, user friendly and energy efficient . There is a great awareness of resource conservation associated with architectural designs and building material.

The built environment is a major contributor to the greenhouse effect and environmental threats. Buildings use energy for lighting, heating, cooling, air handling and air conditioning. and through this they contribute to the greenhouse effect. They also use huge amounts of non-renewable resources. Green Architecture is the architecture of the future, which deals with the relationship of the built environment to the natural environment. This policy considers the issues of air quality, material selection, planning, education and advocacy. The following sustainable policies are recommended for building design to:

1. Reduce CO2 production and the associated impact on the Greenhouse Effect and Climate change
2. Reduce the use of tropical hardwood in buildings' construction as tropical rainforests have a vital impact on global climate change.
3. Reduce non-renewable resource depletion.
4. Increase the quality of the built environment by maintaining and enhancing the natural environment and reducing the impact of negative macro design aspects.
5. Increase the quality of the internal environment and so increase user satisfaction and reduce working-induced illness.
6. Increase the development and use of renewable energy in buildings throughout the built environment system.
7. Encouraging design to achieve density between 20 and 40 persons per hectare by designing mixed use developments within sub-centers of nodal points.
8. Encouraging high rise construction in the Central Business District in urban areas.

1.7 CONCLUSION

The sustainable urban forms of the future will have to be derived largely from our existing buildings and urban systems. The forms of existing cities are significantly different from those of the past. There is a need today to encourage urban development which is user friendly and friendly to the environment. There is a need to apply criteria for sustainability to land use and urban form to transport plans to bring about behavioural change and to the design of the built environment.

Newman and Kenworthy's contribution is to determine empirically the energy efficiency of layouts of the types of urban forms and transport networks already advocated by urban designers, such as Rickaby, Steadman, Barret (1991), Lynch (1981) and others.

As suggested by Lynch (1981), the modern city may take the form of a series of fragmented roads and landmarks. This fragmentation need not be a disadvantage, so long as the fragments are joined by an effective communications network. Reurbanization, as suggested by Berg, Burns and Klaassen (1987), involves not only providing better use of land by controlling urban sprawl but also encourages development which is less automobile dependent.

The reorientation of transport based on planned congestion can be used to help a city become less automobile dependent. Planned congestion can help a city to progress towards lower car dependency and lower energy use through a better balance between public transport, walking and cycling. This approach may be useful for new and existing roads. Planned congestion could offer an opportunity to help contain the outward growth of cities, develop more efficient, shorter travel distances, give priority to public transport, and fundamentally lower automobile dependence and the transport energy use of our cities.

In the past, transportation plans were developed on the principles of efficiency and speed. This approach provided the basis for urban sprawl during the last two decades. Those plans provided for long distance links between new residential development, work places and the city center. However, transport planning today has to be in a framework which provides sustainable urban form and environment as a higher priority than has been the case in the past. Among other things, this has to be followed by a change of priorities in transportation policy towards more public transport.

To achieve sustainability in urban form, it is important to develop goals and policies for efficient use of energy resources and transport infrastructure. This at a city-wide scale may be achieved by pursuing policies of decentralised concentration, reurbanisation, reorientation of transport systems, urban containment, selective intensification, and mixing of land uses at a scale which still provides reasonable choices of jobs and services within a limited area.

CHAPTER 5
DETERMINANT OF ENERGY CONSUMPTION IN URBAN AREAS

5.1 URBAN AREAS IN NEW ZEALAND

In his book **A Destiny Apart, New Zealander's Search for National Identity**, Sinclair stated: *"New Zealanders ... looked to a rural experience for their roots."* Referring to New Zealand attitudes in 1945 he stated:

> *"The towns were seen as merely an encampment of nomads who had broken into the natural order like robbers into a temple, blind to its beauties, proportions or wisdom" (Sinclair, 1992).*

Despite the role of rural New Zealand in the country's history, and the view the New Zealander's value are essentially rural (Aasen 1991, Sinclair 1992), the population is predominantly urban. Some 85% of the population lives in the urban areas of New Zealand.

Due to highly urbanised population in New Zealand, the largest cities are not exempt from the problems of un-sustainability showed by cities throughout the world. They are spreading over agriculturally important land. In some cases, ex-urban development is consuming substantial natural and physical resources, and emitting large quantities of pollution (Land Transport Strategy, 1993).

The density of population in New Zealand is 13 persons per sq km, which is negligible compared to the density of population of 328 persons per sq km in Japan. The density of population of Australia is 2.2 persons per sq km (Census 1991).

The trend toward living in urban areas has been increasing. In 1926, the population living in the main and secondary urban areas was 68% compared to 84% in 1986, and 85% in 1991.

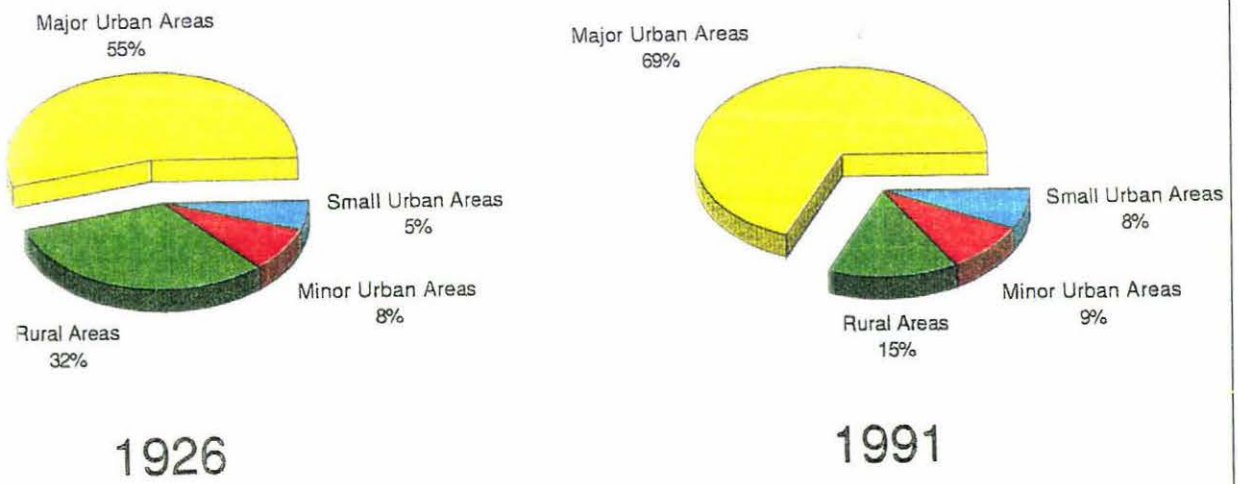
There were 82 cities and boroughs having a population of 1,000 persons and above throughout New Zealand in 1971 compared to 189 in 1986 (Census 1971,1986).

As a result of urbanisation, rural-urban migration and south-to-north migration, big cities are dependent on motorised transport resulting in increased air pollution. Over 40% of New Zealand's total greenhouse gas emissions are produced by road transport. (Horne, 1991).

Figure 5.1 shows the differences in the distribution of population between urban and rural areas in New Zealand in 1926 and 1991. Population trends in main urban areas, secondary urban areas, and minor urban areas from 1926-1991, according to census 1991, and other sources are shown in Table 5.1.

Figure 5.1

Urban And Rural Area Population Comparison



Source: Census of Population, New Zealand 1991

The rural population in 1926 was 32%, compared to 15% in 1991, which indicates a very sharp decline in the rural population within 65 years (Table 5.1). Total urban area population was 68% in 1926, compared to 85% in 1991 which reflects the true urban nature of the country.

Table 5.1 URBAN AND RURAL AREA IN NEW ZEALAND FROM 1926-1991

Area	No & %	1926	1945	1966	1976	1986	1991
URBAN							
Major	No	765,519	1,001,820	1,729,302	2,113,779	2,230,847	2,356,410
Urban	%	55	58	65	68	68	69
Areas							
Secondary	No	75,362	91,471	177,949	218,296	226,582	261,060
Urban	%	5	5	7	7	7	8
Areas							
Minor	No	117744	140570	245500	290620	311175	316015
Urban	%	8	8	9	9	9	9
Areas							
TOTAL	No	958625	1233861	2152751	2622695	268604	2933485
	%	68	73	81	84	84	85
RURAL	No	443049	465284	519357	502428	535107	501510
	%	32	27	19	16	16	15
GRAND	No	1401674	1699145	2672108	3125123	303711	3435000
TOTAL	%	100	100	100	100	100	100

Source: Census of Population New Zealand

Table 5.2 shows that New Zealand is more urbanised than Canada and Switzerland, and almost six times more than Kenya. Belgium, the United Kingdom, Australia and New Zealand stand out as highly urbanised countries.

Table 5.2 INTERNATIONAL COMPARISON OF URBAN AND RURAL AREAS

COUNTRY	YEAR	% OF URBAN POPULATION	% OF RURAL POPULATION
Belgium	1988	96	4
United Kingdom	1988	92	8
Australia	1988	86	14
New Zealand	1991	85	15
Canada	1988	76	24
Switzerland	1988	58	42
Samoa	1981	21	79
Kenya	1981	15	85

Source: Census of Population 1991, New Zealand

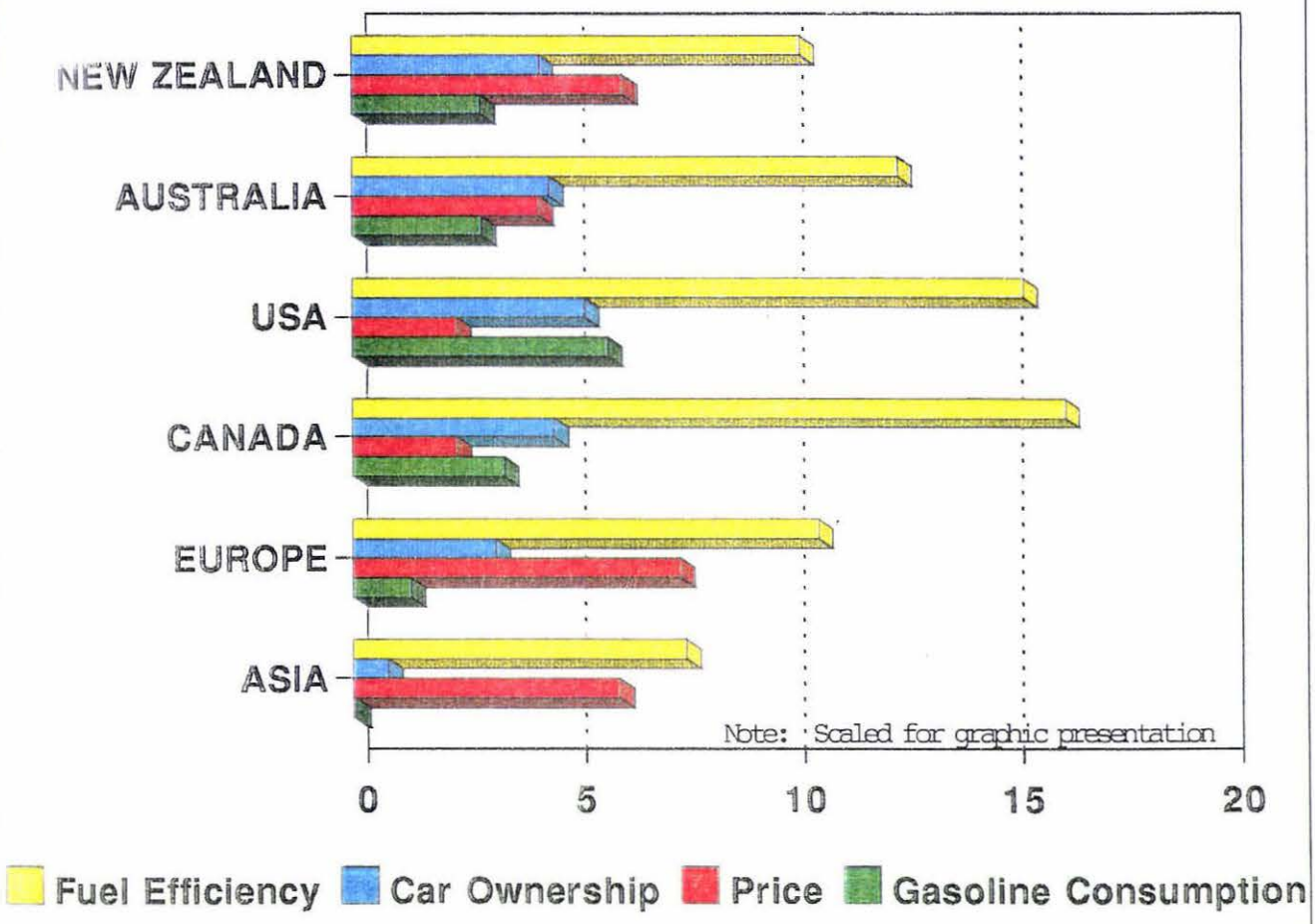
5.2 FUEL CONSUMPTION AND MODE OF TRANSPORT

The diffusion of private vehicles has increased the consumption of fossil fuel. This poses a major resource and sustainability threat in immediate terms to most of the countries of the world (Whitelegg, 1989). Consumption is growing faster than resources are being extended in most parts of the world. Many argue that the most economic solution to this threat is to reduce automobile use by such things as supporting ride sharing and encouraging alternatives to motorised forms of transport, such as walking and cycling. For this to be effective would require a complete change in the system to motivate people to use public transport and alternative modes at a time when the form of the city appears to depend more and more on the flexibility of the private vehicle.

Figure 5.2 demonstrates sharp contrasts in car usage and, by implication, gasoline dependence among various countries and regions; including, New Zealand, Australia, USA, Canada, Europe and Asia. Again, the trend of urban development in the United States illustrates that the average U.S. city uses nearly double the gasoline per capita of Australian and New Zealand cities, a little less than double Toronto's usage, four times more than in European cities, and ten times the average of Asian cities.

Figure 5.2

CAR OWNERSHIP, FUEL EFFICIENCY, PRICE AND GASOLINE CONSUMPTION IN DIFFERENT COUNTRIES OF THE WORLD



Source: Patterson 1991
Newman & Kenworthy 1989

Gasoline consumption is highest in the United States of America and lowest in Asia, and almost identical in New Zealand and Australia. The gasoline price is the lowest in USA and Canada and the highest in New Zealand, Asia and Europe. A high gasoline price has an impact on efficiency by encouraging a preference for small engine sizes. Thus, cars in the USA and Canada are less fuel efficient than cars in Australia, New Zealand, and Europe. Vehicles in Asia are more than twice as fuel efficient as cars in the USA and Canada because of smaller average engine size.

Car ownership is highest in the USA and Canada ie. 533/1,000 population and 463/1,000 respectively. Car ownership is also very high in Australia (453/1,000) and New Zealand (507/1,000) compared to other countries in the world. Only 88 cars are available for every 1,000 population in Asia. It is the interaction of indicators of car dependence, vehicle efficiency and fuel price with urban form which will influence the sustainability of city development.

5.3 POPULATION AND DENSITY RELATIONSHIPS

The main parameter describing the form of a city is its density, which has significant effects on travel distances and modal split. The overall shape of the US, Australian and New Zealand automobile city is of low density population. Europeans cities are three to four times more dense than cities in USA, Australia, Canada, and New Zealand (Table 5.3). Boston and New York cities, due to their role as international commercial centers, have very high central city density as compared to the other US cities. Paris has the highest cental city density and Hong Kong has the highest whole city density among all cities.

It is interesting to note that whole city density in USA, Australia and New Zealand ranges between 9-20 persons per hectare. However, central city density in cities of the USA, Australia and New Zealand range from 6 persons per hectare to 25 persons with the exception of four out of 20 cities. Table 5.3 also shows that Frankfurts is the smallest city included in the study having a population of 631,287. Auckland has overall and net densities of population comparable with Frankfurts.

The overall form of the U.S and New Zealand automobile cities tend to give low central city densities and comparable total city densities with European and cities generally. Auckland is more like the U.S. and Australian cities in its profile, at 20 persons per hectare central city density. In European cities, the central city density ranges between 26 and 235 persons per hectare and in Asia the density ranges between 82 and 204 persons per hectare.

TABLE 5.3 POPULATION AND DENSITY RELATIONSHIPS

Cities	Total City POP.	Centre City POP.	Total City DENSITY (per ha)	Central City DENSITY (per ha)	Central City POP. (%)
AUSTRALIA					
Perth	898.918	6,392	11	8	.71
Adelaide	931.918	1,819	13	8	.20
Brisbane	1,028.527	2,531	10	15	.24
Melbourne	2,722.817	3,375	16	25	.12
Sydney	3,204.696	4,440	18	11	.13
USA AND CANADA					
Phoenix	1,509.052	6,724	9	17	.45
Denver	1,593.308	7,050	12	19	.44
Toronto	2,137.395	4,742	40	25	.22
Boston	2,763.357	71,557	12	126	2.6
Houston	2,905.353	2,145	9	6	.07
Washington	2,988.100	3,458	13	8	.11
San Francisco	3,250.630	34,338	16	90	1.06
Detroit	4,043.633	4,046	14	11	.1
Chicago	7,103.624	6,462	18	16	.09
Los Angelus	7,477.503	9,516	20	29	.08
New York	17,925.200	506,100	20	217	2.8
EUROPE AND USSR					
Frankfurts	631,287	15,572	54	65	2.4
Amsterdam	716,900	69,400	51	108	2.4
Zurich	780,502	6,750	54	44	.86
Brussels	997,293	19,180	67	74	1.9
Munich	1,298,941	77,172	57	111	5.9
Stockholm	1,528,200	41,146	51	97	2.7
Vienna	1,531,346	19,537	72	65	1.2
Hamburg	1,645,095	12,153	42	26	.73
Copenhagen	1,739,860	38,571	30	85	2.2
West Berlin	2,001,000	16,000	64	133	.79
London	6,713,200	179,000	56	66	2.7
Moscow	8,015,000	?	139	155	?
Paris	10,094,000	548,620	48	235	5.4
ASIA					
Singapore	2,413,945	157,300	83	204	6.5
Hong Kong	4,986,560	17,287	293	160	.3
Tokyo	11,597,211	337,644	105	82	2.9
NEW ZEALAND					
Auckland	939,003	1,473	46	20	.15
Wellington	325,682	2,400	43	18	.7
AVERAGE					

Source: Newman and Kenworthy 1989, Census of Population 1981, 1991.
New Zealand, reports of respective City councils.

The central city population in Auckland is negligible compared to the central population in Europe and Asian cities. Total city density of population ranges between 43-46 persons per hectare in New Zealand which is quite comparable to the US and European city's densities. This comparison is a true indication of the low density urban form of Auckland which fosters private transport.

5.4 POPULATION AND JOB DISTRIBUTION

New Zealand cities like the U.S. and Australian cities, have a high job concentration and generally few residents in the CBD. European and Asian cities have a balance between central city jobs and residences.

On the basis of the distribution of population and jobs, Kenworthy and Newman identified whether the 32 cities they studied are centralised or dispersed in their land use patterns. The American and Australian cities clearly have a very small proportion of their total population residing in the central area. The U.S. cities overall are higher than the Australian cities but only because Boston and New York have a comparatively high proportion of central city residents. Without these two cities, the U.S. and Australian cities average out at 0.3% of the total population living in the CBD. The figure for the European cities is ten times higher. In terms of the proportion of jobs in the central area, the data ranges from around 4 to 10% in the heavily suburbanised, decentralised cities like Phoenix, Denver, Houston and Los Angelus and up to around 30% in highly centralised cities like London, Tokyo and Amersterdam (Table 5.4).

The U.S. cities are the least centralised in their jobs, followed by the Australian and New Zealand cities. Thus, although the auto-based U.S. and Australian cities have concentrated their CBD jobs into high rise office buildings. There is still a high proportion of total employment which tend to be dispersed in a low density pattern throughout the city.

In New Zealand cities, the proportion of the population living in the CBD is largely the same as in Australian and American cities. In the case of Auckland, the CBD is continuos with the inner urban area and thus reflects a higher concentration of jobs. The percentage of the population in both the CBD and inner area that is of working age is 34%. The proportion of population in inner city areas

is lowest in the Australian cities, followed by the U.S. and Asian cities, Toronto and European cities (16%, 26%, 33%, 36% and 42% respectively). The proportion of population in the inner area of Auckland urban area falls in the range of American and European cities.

The proportion of jobs in the inner areas is clearly lowest in the U.S. cities despite their generally larger areas (ie. 36% compared to 41% in the Australian cities). The U.S. cities have seen more suburbanisation of jobs to large industrial parks and greenfield estates. By contrast the European cities have nearly 60% of their employment located in their inner areas. However, there is a trend of outward migration of jobs. In general the U.S. cities are the least centralised cities, followed by the Australian and New Zealand cities, and European cities. The proportion of jobs in the inner area of Auckland is 59% which reflects less trends toward outward migration of jobs. The problem is to retain the present level of jobs in the inner area and provide appropriate and energy efficient modes of transport to sustain the present supply of jobs and anticipated job growth.

TABLE 5.4 INTERNATIONAL COMPARISON OF WHOLE CITY AND CENTRAL CITY POPULATION VERSUS JOBS

Cities	Whole City Density POP.	Whole City JOBS	Central City Density POP.	Central City JOBS	Proportion of Pop in whole City (%)	Proportion of Jobs in CBD (%)
AUSTRALIA						
Perth	11	5	8	121	.7	24.1
Adelaide	13	5	8	251	.2	14.4
Brisbane	10	4	15	346	.3	13.9
Melbourne	16	6	25	647	.2	15.2
Sydney	18	8	11	434	.1	13.2
AVERAGE	14	6	13	360	.3	12.3
USA AND CANADA						
Phoenix	9	4	17	67	.5	3.9
Denver	12	8	19	263	.4	11.6
Toronto	40	20	25	757	.2	13.4
Boston	12	6	126	383	2.7	15.9
Houston	9	6	6	443	.1	11.6
Washington	13	8	8	584	.1	16.1
San Francisco	16	8	90	713	1.1	17
Detroit	14	6	11	306	.1	6.6
Chicago	18	8	16	938	.1	12.3
Los Angelus	20	11	29	472	.1	4.8
New York	20	9	217	828	2.8	22.9
AVERAGE	14	7	54	500	.8	12.3
EUROPE AND USSR						
Frankfurts	54	43	65	389	2.5	18.4
Amsterdam	51	23	108	153	9.7	29.9
Zurich	54	33	44	422	.9	13.6
Brussels	67	42	74	592	1.9	24.6
Munich	57	34	111	231	5.9	20.5
Stockholm	51	34	97	280	6.4	26.3
Vienna	72	38	65	403	1.3	14.9
Hamburg	42	24	26	407	. 7	20
Copenhagen	30	16	85	325	2.2	16
West Berlin	64	27	133	333	.8	4.8
London	56	30	66	397	2.7	29.7
Moscow	139	?	155	?	?	?
Paris	48	22	235	400	5.4	20.2
AVERAGE	54	31	92	361	3.4	19.9
ASIA						
Singapore	83	37	204	339	6.6	24.3
Hong Kong	293	110	160	1,250	.4	7.3
Tokyo	105	66	82	477	1.3	26.6
AVERAGE	160	71	149	692	2.8	19.4
NEW ZEALAND						
Auckland	46	32	20	24	.45	14.8
Wellington	43	30	18	32	.42	—
AVERAGE	44.5		19	28	.4	15.0

Source: Newman and Kenworthy 1989, Census of Population 1981, 1991.
New Zealand. reports of respective City councils.

5.5 CITIES AND GASOLINE CONSUMPTION

The private vehicle is the dominant mode of transport in New Zealand's cities, as in cities of the USA and Australia . In the case of New Zealand cities, their motorway systems were developed in the 1950s. This encouraged suburban growth and led to sprawling, low density urban form. As a result of suburban development, services are widely spread reinforcing reliance on private transport and reducing the effective use of public transport.

There is a strong relationship between gasoline consumption and urbanisation. High rise office blocks in U.S. and Australian cities have little overall effect on transport patterns despite the importance of peak hour traffic activity. It is, however, important to have higher residential densities mixed in with employment activity to reduce gasoline demand. Residential density in the central city strongly supports all the transport patterns, including walking and bicycling. The more dense the urban area, the more bicycling and walking will be used as a mode of transport to work and other activities.

The relationship between population density and gasoline use is important in terms of transport energy saving to curtail private car use. Newman and Kenworthy study found cuts off density (sustainable density) of around 30 persons per hectare to be significant for transport energy saving within different parts of the urban areas. The critical density of population which Kenworthy and Newman derived for less automobile dependant cities suggested that if cities with densities of around 10 person /ha were able to consolidate and move to densities of around 30 person/ha, fuel consumption could be one third or even one half of its low density value.

Based on the data, Newman and Kenworthy drew a curve showing the relationship between gasoline consumption per capita and urban density. Figure 5.3 includes Auckland and Wellington onto their graph.

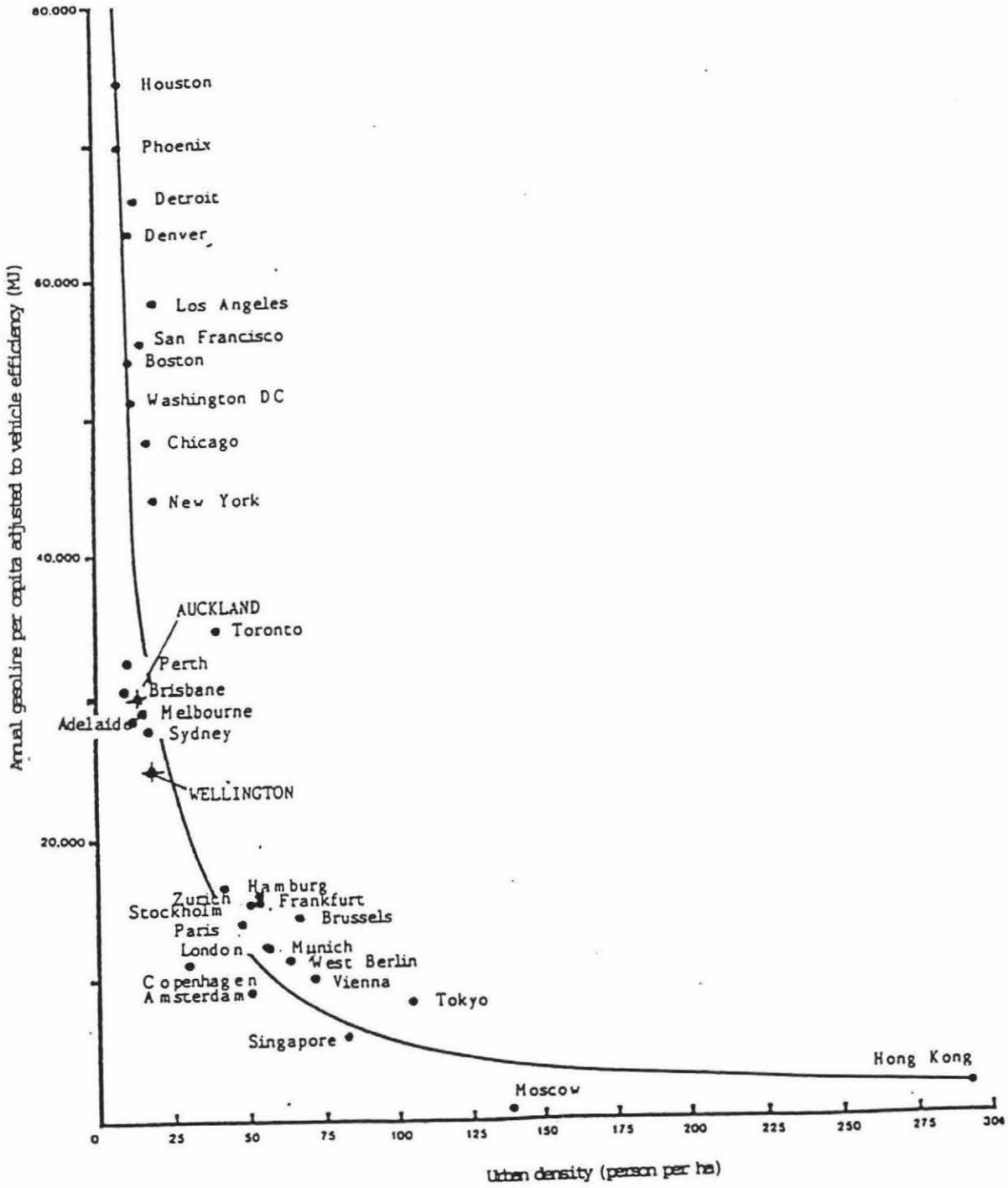
The Auckland and Wellington per capita gasoline consumption data was obtained from the Energy End Use Database for New Zealand Economy 1993 and Census 1991 data. The New Zealand's cities of Auckland and Wellington have very similar population net densities at about 20 persons

per hectare, which are comparable to the densities of population in the USA and Australian cities. Energy use per head in Auckland is 10% higher than in Wellington and slightly higher than Melbourne, Adelaide and Sydney.

Questions arise as to why Wellington is more fuel efficient than Auckland? All the above Australian cities and Wellington have rail systems but Auckland does not. Public transport is the deciding factor in the above comparison, which makes the difference in fuel efficiency. The proportion of Australian commuters using public transport was 12% in the least energy-efficient city and 29.5% in the most efficient (Newman & Kenworthy 1991). In Wellington modal split gives 20% on public transport in 1991 as against 10% in Auckland (NZ Census 1991). Improvement in public transport and the rail system, in particular, is surely a way of achieving more fuel efficiency in Auckland.

Figure 5.3

Gasoline Use (MJ) Per Capita Versus Urban Density (persons/hectare)



Source: Newman & Kenworthy 1991, Census of Population New Zealand 1991, Energy End Use Database for New Zealand Economy 1993

5.6 TRANSPORT PREFERENCES

The most economic solution to the fossil fuel supplies threat is to reduce automobile use, by encouraging alternatives to motorised forms of transport, such as walking and cycling. It implies a complete change in the system to motivate people to use public transport and alternative modes at a time when the form of the city appears to depend more and more on the flexibility of the private vehicle. The evidence suggests a trend towards more, not less use of private transport due to modernisation and urbanisation.

American cities average only 5% of total passenger travel by public transportation, 84% of people use cars for journey to work and 4% foot or bicycle. Among the most extreme cases, public passenger transport accounts for only .8% in Houston and Detroit and only .5% in Phoenix. Australian cities are comparatively less automobile orientated. On average, public transport accounts for 19% of journey to work, car use for 73% and foot or bicycle for 5%. Public transport accounts for 12% of journey to work, foot or bicycle 9% and car use for 79% in New Zealand cities (Douglas & Nuttal, 1992). In European cities 25% of journey to work by public transport, 35% use cars and 21% use foot or bicycle (Newman & Kenworthy, 1989).

The highly automobile oriented American cities are at the top of list in Table 5.5. Car ownership is highest in USA and Canadian cities where they fall between 400 and 700 per 1000. Car ownership is also very high in Australian (400 and 500 per 1,000) and in New Zealand's cities (500 and 600 per 1,000). Car ownership is between 300 and 400 per 1000 in European cities compared with 20 cars per 1000 in Moscow USSR. In Asian countries, car ownership ranges between 40 and 200 per 1000. It is shown in the table that car dependence is very high in cities of the USA, Canada, New Zealand and Australia compared to European and Asian cities where public transport is a mode of transport for the great majority of population.

Table 5.5 POPULATION DENSITY AND GASOLINE CONSUMPTION

Cities	Gasoline Consumption MJ per capita	Car Ownership (per 1,000)	Private Car (passenger kms per capita)	Public Transport (passenger kms per capita)	Private Car/ Public Transport Balance (% of total passenger kms on public transport)
AUSTRALIA					
Perth	32,610	475	11,477	592	4.9
Adelaide	28,791	475	10,625	655	5.8
Brisbane	30,653	458	11,721	745	6.0
Melbourne	29,104	446	10,128	779	7.1
Sydney	27,986	412	9,450	1,511	13.8
USA AND CANADA					
Phoenix	69,908	499	13,170	66	.5
Denver	63,466	666	11,630	218	1.8
Toronto	34,813	463	9,850	1,976	16.7
Boston	54,185	465	12,570	518	4.0
Houston	74,510	603	15,968	128	.8
Washington	51,241	561	11,670	616	5.0
San Francisco	55,365	543	13,200	926	6.6
Detroit	65,978	594	14,017	112	.8
Chicago	48,246	445	11,122	971	8.0
Los Angelus	58,474	542	13,865	384	2.7
New York	44,033	412	7,856	1,285	14.1
EUROPE AND USSR					
Frankfurts	16,,093	387	6,810	1,713	20.1
Amsterdam	9,171	308	4,441	1,801	28.9
Zurich	15,709	375	7,254	2,157	22.9
Brussels	14,744	361	5,706	1,396	19.7
Munich	12,372	360	5,235	1,592	23.3
Stockholm	15,574	347	6,570	2,124	24.4
Vienna	10,074	311	4,262	1,828	30.0
Hamburg	16,671	344	7,470	1,516	17.0
Copenhagen	11,106	246	6,231	1,657	21.0
West Berlin	11,331	269	4,572	2,159	32.1
London	12,426	288	4,452	1,717	27.8
Moscow	380	20	230	4,262	95
Paris	14,091	338	4,199	1,827	30.3
ASIA					
Singapore	6,003	65	1,789	1,942	52.1
Hong Kong	1,987	42	615	2,043	76.9
Tokyo	8,488	156	2,993	5,191	63.4
NEW ZEALAND					
Auckland	29,562	560	13,600	725	5.3
Wellington	26,769	507	11,400	1,440	12.6

Source: Newman and Kenworthy 1989, Census of Population 1981, 1991.
New Zealand, reports of respective City councils. Energy End-Use Database of the New Zealand Economy.

Total passenger kms on public transport in various cities around the world fall between 5% and 13% in New Zealand, 5% and 14% in Australia, .8% and 14% in USA and .5% and 17% in Canada. Total passenger kms on private transport per capita in various cities around the world ranges between 11,000 and 14,000 kms. The total passenger kms on private transport in New Zealand cities ranges between 9,000 and 12,000 kms, 9,000 and 14,000 kms in Australia, 12,000 and 16,000 in Canada and USA, and between 200 and 8,000 kms in cities of Europe and USSR.

There is no reason to expect this high dependence on private vehicles to diminish in New Zealand. The total number of vehicles registered grew from 1,504,580 in 1971 to 2,349,270 in 1991 (Motor Vehicle Registration Centre,1991) or 2.8% per annum on average. Table 5.6 shows motor vehicles licensed from 1971-1991 under various categories in New Zealand. The number of cars increased from 928,423 to 1,539,809 between 1971 and 1991, a 40% increase. The number of taxi cabs increased by 3% from 1971 to 1991 and miscellaneous and commercial vehicles increased by 30%. Cars grew rapidly (3.9% annual average increase) against a population growth of 3.5. Car usage comprised 66% of the total New Zealand vehicle fleet by 1991.

Table: 5.6 LICENSED MOTOR VEHICLES IN NEW ZEALAND (1971-1991)

Type of Vehicle	1971		1981		1991		Increase	
	No	%	No	%	No	%	No	%
Cars	928,423	62	1,309,072	60	1,539,809	66	611,386	72
Taxi	3,142	.2	3,211	.14	3,250	.14	108	.01
Motorcycle	61,314	4	151,976	7	73,546	3	12,232	1.4
Miscellaneous & Comm-ercial Vehicle	511,697	34	755,530	33	732,664	31	220,967	26
TOTAL	**1,504,576**	**100**	**2,219,789**	**100**	**2,349,269**	**100**	**844,693**	**100**

Source: Motor Vehicle Registration Center, Palmerston North, 1991.

5.7 MODE OF TRANSPORT AND TRAVEL TO WORK

As already mentioned, higher densities are in each case associated with a greater proportion of people using public transport, foot and bicycle to work. The proportion of jobs in city centers is one of the key factors behind developing a vital public transport system. Similarly the relationship between the number of jobs in the city center and public transport does in fact show a much greater significance.

Tables 5.7 and 5.8 show that the majority of people use private cars/trucks/vans as a mode of transport to work in 1981 and 1991 in Auckland, Wellington, Christchurch and Dunedin. Private car use was a popular mode of transport to get to work in 1981 when more than 50% of the population was using this mode in Auckland, Christchurch and Dunedin. Travel to work data for Wellington shows that 42% used private cars, 11% used commuters trains, and 13% used other forms of public transport to get to work which is true indication of the popularity of public transport. During 1991 the use of private transport to get to work was even greater and more than 63% of the population was using this mode of transport in Auckland compared to 48% in Wellington, 60% in Christchurch and 59% in Dunedin.

Public transport was a popular mode of transport for 24% of the population in Auckland 36% in Wellington, 16% in Christchurch and 22% in Dunedin in 1981. Trucks and buses are included in the above figures as a public transport. Walking was a mode of transport for 10% of population in Wellington and 12% in Dunedin compared with 7% in Auckland and 6% in Christchurch in 1981. However, cycling is a static mode of transport (between 2% and 3%) for travel to work in Auckland, Wellington and Dunedin but, account for 10% of total journey to work figures in Christchurch in 1981.

The trend of working from home was static between 1981 and 1991 and therefore, reduction in fuel use is not expected through new technologies and availability of advanced tele-communication facilities. The proportion of population who did not work increased in all four urban centres between 1981 and 1991.

Private transport is gaining popularity in Auckland, Christchurch and Dunedin where more than 60% of commuters people are using this mode transport for travel to work. Commuting is another big reason behind high use of private transport. People living in one part of city and working in other parts of the same city are travelling to work on private transport because of non availability of proper public transport. Public transport use generally declined from 24% to 13% in Auckland, 36% to 29% in Wellington, 16% to 9% in Christchurch and from 22% to 12% in Dunedin between 1981 and 1991.

The popularity of public transport in Wellington is due its well developed local rail system which accounts for 29% of journey to work. The public transport factor appears to have a strong relation with both density and centralisation which determine the viability of public transport and thus a less automobile dependent city. The low density Auckland urban area has comparatively less density of population to support very expensive public transport mode such as local rail systems compared to Wellington and European cities.

Table: 5.7 TRAVEL TO WORK IN FOUR CITIES OF NEW ZEALAND 1981

Mode of Transport	Auckland		Wellington		Christchurch		Dunedin	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Did not work	17,973	5	5,337	3	6,495	5	1,656	4
Public transport	43,674	13	20,949	13	11,550	9	4,347	9
Train	3,867	1	17,385	11	18	0	429	1
Drove car/ truck/van	180,714	53	68,028	42	67,587	50	24,009	52
Passenger in car/truck/or bus	35,541	10	19,605	12	9,795	7	5,340	12
Bicycle	7,149	2	4,440	2	13,797	10	1,251	3
Motor/ power cycle	8,739	3	2,925	3	9,153	7	1,818	4
Walked	24,069	7	15,243	10	8,475	6	5,526	12
Other means	2,130	1	816	1	501	0	144	0
Work at home	1,2894	4	4,002	2	6,528	5	1,623	4
Not specified	2,748	1	1,575	1	1,005	1	204	0
TOTAL	**339,498**	**100**	**160,305**	**100**	**134,904**	**100**	**46,347**	**100**

Source: New Zealand Census of Population 1981

Table: 5.8 TRAVEL TO WORK IN FOUR CITIES OF NEW ZEALAND 1991

Mode of Transport	Auckland		Wellington		Christchurch		Dunedin	
	No	%	No	%	No	%	No	%
Did not work	36,129	10	7,737	8	12,954	11	4,536	10
Public transport	23,376	6	9,858	11	5,241	4	1,779	4
Train	1,500	0	7,524	8	21	0	12	0
Drove car/ truck/van	239,325	63	43,965	48	74,175	60	25,704	59
Passenger in car/truck/or bus	25,650	7	9,129	10	6,297	5	3,366	8
Bicycle	6,738	2	1,290	1	10,503	9	1,215	3
Motor/ power cycle	3,576	1	1,146	1	2,976	2	717	2
Walked	16,206	4	7,740	7	4,824	4	3,681	9
Other means	5,628	1	996	1	726	1	276	1
Work at home	15,309	4	2,241	2	4,020	3	1,665	4
Not specified	5,625	1	573	1	690	1	276	1
TOTAL	**379,062**	**100**	**92,199**	**100**	**122,421**	**100**	**43,227**	**100**

Source: New Zealand Census of Population 1991

5.8 CONCLUSION

The relationships between income and transport energy consumption is not simply a function of car ownership. It is also affected by changing patterns of land use associated with income and wealth. Studies of the relationship between energy consumption and land use attempt to assess how different urban form may affect the amount of energy used. The relationship between energy use and urban form has been studied by Owens (1992) by developing four approaches for analysing traffic implications of various settlement patterns. In the first approach, energy use is assumed to be based on modal shares, trip distance, and vehicle occupancy. This approach is based on survey data of distances travelled per person per week by mode. In the second approach, energy consumption is assumed to be a function of modal shares, trip distances and settlement types using household-level data. In the third approach, energy use is assumed to be a function of density and intensity of land use. The data collected by Newman and Kenworthy (1989) for different world cities was used to establish a relationship between fuel use and urban density or job density. In the fourth approach, energy use is assumed to be predominantly a function of the journey to work catchment. For this purpose, Census data can be used to establish labour market catchment areas and the proportion of people living and working in the same area.

On the basis of the four approaches investigated, some tentative principles can be advanced about the relationship between transport, energy and settlement patterns and journey to work. For example, travel distances and trip rates should be reduced so that residential areas can be related to local jobs and services and not developed as dormitory suburbs. Another option to reduce the physical separation of activities is to decentralise some jobs and services and relate them to residential areas within a single large urban area. A variant is to form freestanding settlements which may or may not retain links with the original center. This implies a greater diversity of land use within the built areas. This is based on the belief that concentration of new developments in smaller centers outside the urban area is less costly and more effective because of reduced levels of traffic congestion and the greater availability of space. This does not make any particular assumption about the nature of activities within the new centres, but focuses on

the impacts of urban scale. It implies that big cities are less fuel efficient because of congestion and land use separation.

There is also a strong relationship between vehicle ownership and urban form. As population and job densities and the relative importance of central and inner areas increase, total vehicles per household and the traditional car ownership factors decrease in a significant way. Car ownership is low in more compact and centralised cities. The difference observed may simply be a function of relative wealth. Increasing densities and thereby reducing car dependence in the wealthy industralised nations is unlikely to be effective.

Density and centralisation of different activities appear to be clear factors which determine the viability of public transport and thus a less automobile dependent city. Public transport particularly in the form of rail system in big urban centres can increase fuel efficiency. Walking and cycling may bring about a slight change in fuel consumption in urban areas.

A review of approaches related to urban consolidation and containment indicate that there are strong relationships between urban form, transport and energy consumption. It is concluded that containment of activities based on nodes within cities reduces the levels of energy consumption. It is also concluded that the locations with the highest levels of containment will have the lowest levels of energy consumption.

CHAPTER 6

LAND USE AND TRANSPORT IN AUCKLAND URBAN AREA

6.1 AUCKLAND URBAN AREA

Auckland is the fastest growing region in New Zealand. Its population and labour force are growing at twice the New Zealand rate. The diverse natural environment, equitable climate, good rainfall, and rich soils have made Auckland an attractive place for habitation for the last 1,000 years.

The current wave of development dates from European settlement after 1840. Today, one million people live in Auckland, the most populous region in New Zealand. Auckland contains 28% of New Zealand's total population and 32% of the nation's work force. The Region continues to attract migrants from overseas and from the rest of New Zealand. As a result, Auckland will continue to grow and dominate New Zealand's growth. Increasing population and economic development places tremendous pressure on the region's natural and physical resources and environmental quality.

Traditionally, the Auckland region is divided into four zones ie Central, West, North and South Auckland (Map 6.1). These four zones will be used for the description of land use and transport planning in Auckland. Previous and current plans are then evaluated against the criteria for sustainable land use and transport planning outlined in chapter 4.

6.2 POPULATION TRENDS IN AUCKLAND

The population of New Zealand increased by 4.1 percent from 1981 to 1986 and by 3.7 percent between 1986 and 1991, to a total of 3,435,000 persons. The population of Auckland increased by 7.3 percent and by 7.8 percent over the same two periods, reinforcing its dominance of the country's population figures.

Table 6.1 POPULATION DISTRIBUTION IN FOUR ZONES OF AUCKLAND

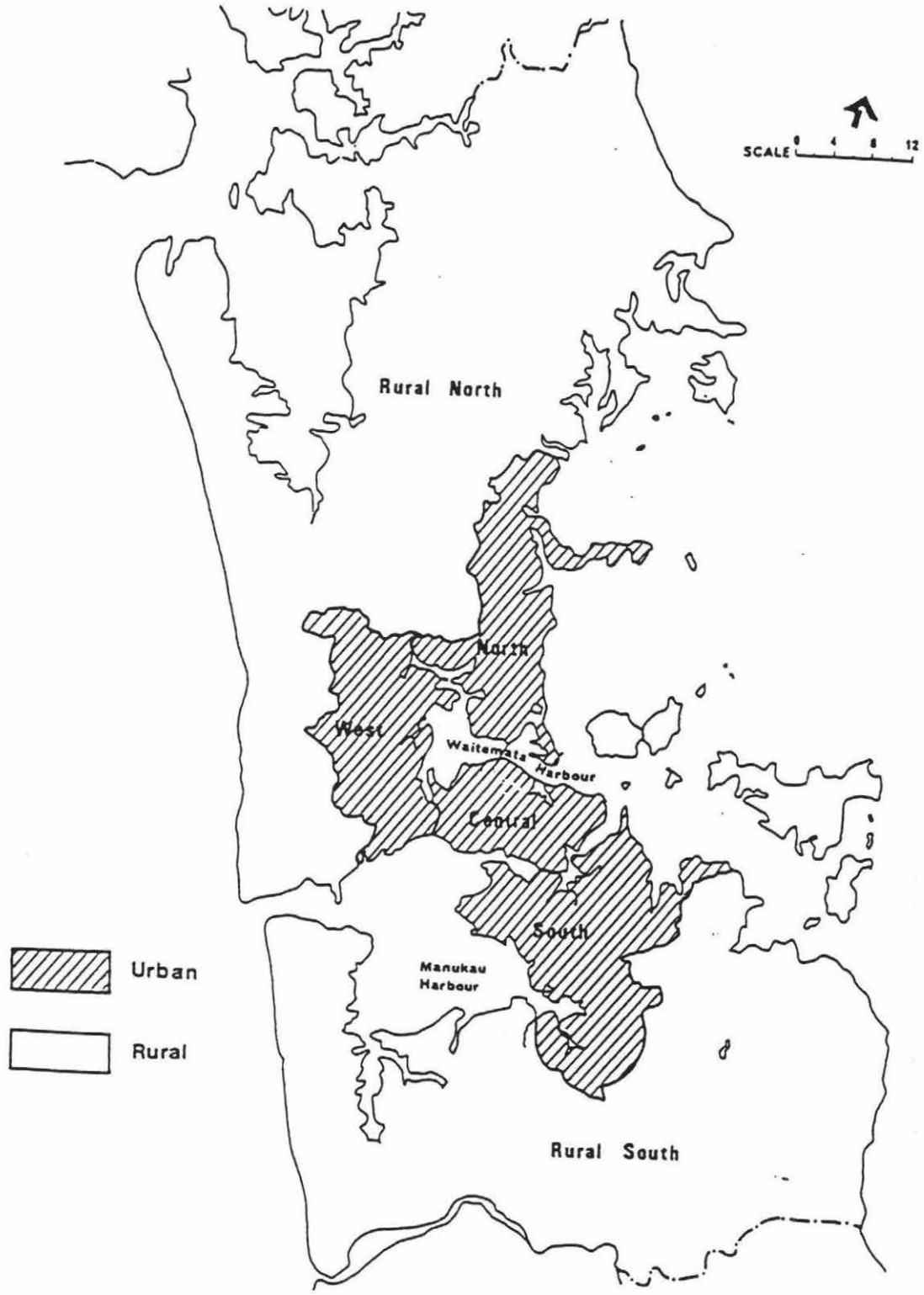
Zones	1971		1981		1991		Pop. Change 1971-1991	
	No	%Share	No	% Share	No	% Share	No	% Share
CENTRAL	286,800	44	275,914	36	331,074	35	44,274	15
NORTH	107,950	17	149,321	19	186,997	20	79,047	27
WESTERN	89,950	14	116,407	15	137,984	15	48,034	17
SOUTH	165,050	25	227,916	30	282,948	30	117,898	41
TOTAL	**649,750**	**100**	**769,558**	**100**	**939,003**	**100**	**289,253**	**100**

Source: Census of Population 1971,1981,1991

Table 6.1 shows regional population trends from 1971 to 1991 in all four zones within Auckland. These illustrate significant growth contrasts within Auckland. According to the 1991 Census 331,074 persons were living in Central Auckland, which accounts for 35% of the total population of the combined Auckland Urban Area. The South Auckland area accounted for 30%, North Auckland 20% and West Auckland for 15% of the total metropolitan population. The percent share of population living in Central Auckland decreased by 9% and increased by 5% in the South, 3% in the North and I% in the Western urban zones between 1981 and 1991. The decline of population in the Central Zone indicates the tendency to decentralisation and the more rapid growth of suburbs compared with the longer-established center of Auckland. This change in living patterns reflects less dependence on public transport and more reliance on private vehicles which, in turn, results in more fossil fuel use, more land consumption and adverse environmental effects. The statistics show the diminishing share of population in Central Auckland while there have been slight increases in other urban zones within metropolitan Auckland between 1971 and 1981.

Map 6.1

Auckland Metropolitan Area



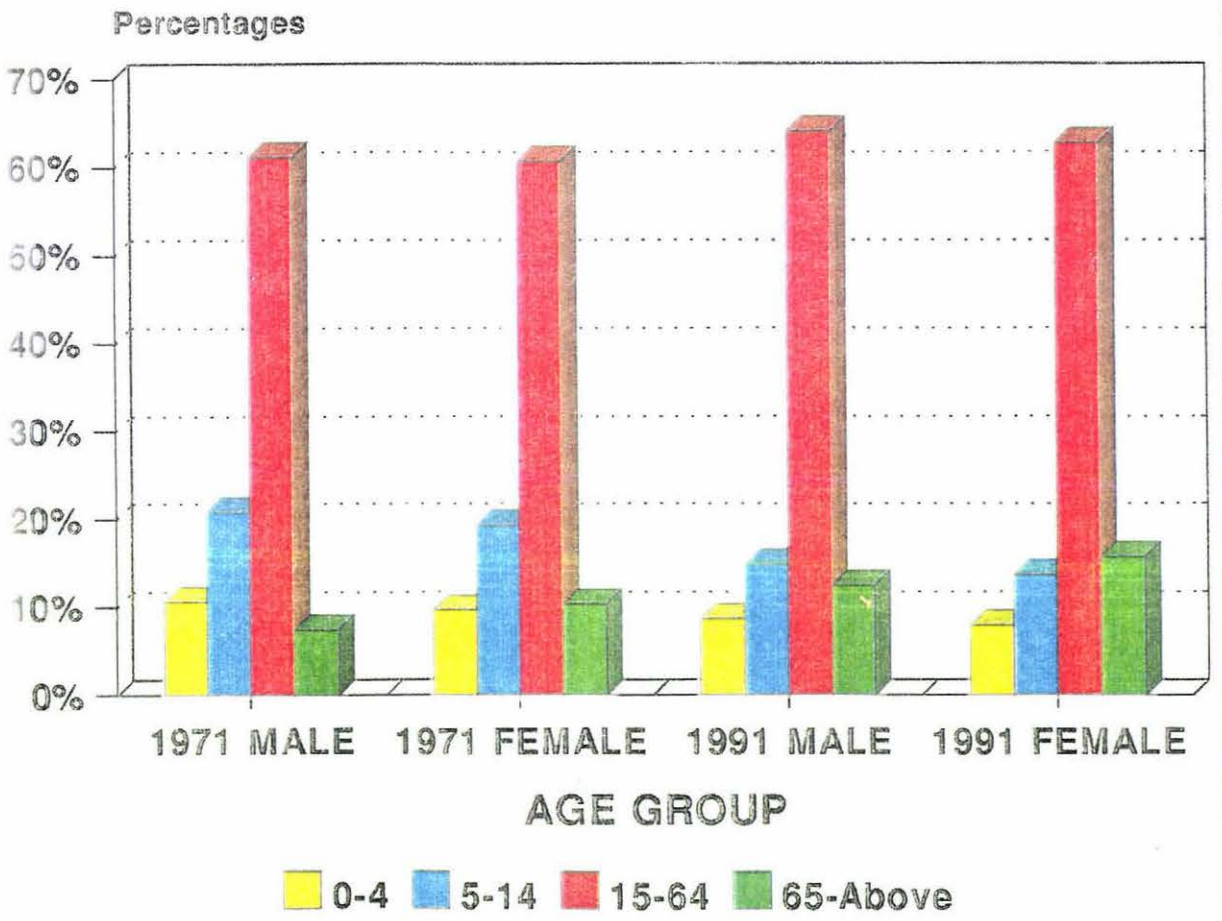
Source: Auckland Transport Study 1991

6.3 POPULATION BY AGE

Figure 6.1 shows the population distribution by age and sex in 1971 and 1991. Some 61% of both the male and female population fell into the working age group (15 to 64 age) in 1971 compared with 64% male and 63% female in 1991. The post working age group in 1991 accounted for 5% more than it was in 1971. The growth in the working age group reflects both in-migration into Auckland and the natural aging of the population.

Figure 6.1

POPULATION DISTRIBUTION BY AGE 1971-1991



Source: Census of Population New Zealand 1991

6.4 ROLE OF OVERALL AND NET DENSITIES OF POPULATION

Auckland's low density development results in expansive use of land for residential, commercial, industrial and transport activities. One of the questions examined in the next section is the relationship between transport demand and urban form.

Overall density is the total population divided by total urban area. **Net** density relates more directly to residential areas. It excludes all non-residential land, whether urban or rural, but includes urban streets serving the residential area. Net density is relevant to residential amenity and local (neighbourhood level) interaction and transport activities. Overall density is more relevant to measurement at the metropolitan level.

Overall population density in Auckland lies between 4 and 20 persons per hectare in all four zones (Table 6.2). However, the net density falls within the range of 30 and 55 persons per hectare. Central Auckland has the highest overall density of population, at 20 persons per hectare, among all four zones of Auckland. The net density of population increased rapidly in Western Auckland from 35 persons in 1971 to 55 persons per hectare in 1991. However, the net density remained static in Central Auckland.

Between 1971 and 1991, the overall densities of population have increased in all four zones, subsequently net density in all four zones. The net densities of population have increased; 33% in North, 36% in West, 3% in Central, and 17% in South Auckland during 1971-91.

These densities of population in Auckland provide a basis for comparison with the critical overall density of 30 to 40 persons per hectare identified from a study of 32 urban areas by Newman and Kenworthy (1989) for less auto-mobile dependent cities. In their study, they selected cities having well-defined CBD's, distinguishable inner urban areas and outer urban areas. For comparative purposes, Auckland is defined as follows:

I) Central Business District (CBD)

The CBD is the core of commercial activity in Auckland, surrounded by highways and arterial roads. This district basically represents the traditional downtown with a few residential activities and major social, educational, cultural and commercial development. Auckland's CBD, unlike the Central Business Districts in American and Australian cities, has a low residential density but high transport needs due to concentrated commercial activity.

II) **Inner Business Zone (IBZ)**

The IBZ is a mix of commercial and residential activities. The Auckland Central area is considered to be the Inner Business Zone for comparison purposes. This zone has moderate residential densities and the same is true with Auckland IBZ.

III) **Outer Business Zone(OBZ)**

The Outer Business Zone has a higher residential density of population than the IBZ. For the purpose of analysis, North, West and South Auckland is considered to be Outer Business Zone.

Table 6.2 OVERALL AND NET DENSITIES OF POPULATION IN AUCKLAND URBAN AREA

Zones	1971		1981		1991		% Change 1971-1991	
	Overall	Net	Overall	Net	Overall	Net	Overall	Net
NORTH	4	30	6	42	8	45	45	33
WESTERN	4	35	6	45	8	55	55	36
CENTRAL	20	38	20	38	20	39	2	3
SOUTH	5	37	6	40	8	45	45	17
REGIONAL FIGURES	**8**	**35**	**10**	**41**	**11**	**46**	**38**	**22**

Source: Census of Population 1971,1981,1991, Auckland Regional Planning Services 1971

6.5 ROLE OF AVERAGE HOUSEHOLD SIZE

The number of dwelling units per hectare is another measure of population density. The proportion of population and jobs found in different parts of the city contributes to relative centralisation. The key point is to know whether land use, particularly residential land use, is centralised or dispersed.

Table 6.3 DWELLING UNITS IN AUCKLAND URBAN AREA (1971-1991)

Zones	1971		1981		1991		% Change 1971-1991	
	No	%	No	%	No	%	No	%
NORTH	33,174	17	50,718	20	63,645	21	30,471	48
WESTERN	24,096	13	35,436	14	46,098	15	22,002	48
CENTRAL	90,929	48	102,141	41	109,989	38	19,060	17
SOUTH	42,407	22	62,235	25	78,528	26	36,121	46
AVERAGE	**190,606**	**100**	**250,530**	**100**	**298,260**	**100**	**107,654**	**36**

Source: NZ Census of Population 1971, 1981, 1991 & Auckland Regional Planning Services 1971

According to the 1991 Census, there are 298, 260 dwelling units in all four Urban areas of Auckland (Table 6.3). Between 1971 and 1981 there was an increase in the number of dwelling units by 35% in the North compared to 32% in the West, 11% in the Central area and 32% in the South of Auckland. The number of dwelling units increased between 1981 and 1991 by 20% in the North, 23% in the West 7% in Central and 21% in the South Zones. Between 1971 and 1991, the number of dwelling units increased by 48% in North Auckland compared to 48% increase in the West, 17% in Central and 46% in South Auckland. It is reflected from the above statistics that greater changes occurred in the urban form in the North, West and South Zones of Auckland as the number of dwelling units doubled during the last two decades. Far fewer were added in the Central Auckland Zone.

Rydin (1992) argues that the optimum density is generally in the range of 30-35 dwellings per hectare based on an average of five bedrooms per dwelling required to achieve the high level

densities to reduce energy efficiency. The main exception is for housing for district heating or for combined heat and power. Owens (1991) suggests that, although optimal density levels are difficult to measure with any certainty, feasibility studies for combined heat and power have mostly favoured dwelling densities of 44 or more dwellings per hectare. It is very difficult to instigate such density changes. Consequently policy analysts using urban simulation models do not generally recognise the potential to alter travel patterns through this type of land use change.

Dwelling densities in Auckland are very low, compared with the optimal density of 30-35 dwelling units per hectare. In a low density urban area like Auckland, it is extremely difficult to achieve the optimal density of 30-35 dwellings per hectare. However, some density changes could be expected from land use changes and by the development of high density multi-family dwellings along major public transport corridors.

To achieve a density of 30 to 40 persons per hectare, we would require a combination of housing types with 60% two to six storey apartments, 20% town houses and 10% single family cluster homes, with 30% of the developed area devoted to open space and recreation. It is also possible to build with all two storey town houses and achieve densities above 30 to 40 persons per hectare, especially when these houses share active open spaces and passive open spaces. However, with low levels of dwelling occupancy as seen in Auckland, it is unlikely that such densities can be reached without some component of medium to high rise apartments.

6.6 EMPLOYMENT CHANGES IN AUCKLAND

Employment growth between 1971 and 1991 was highest in South Auckland (39.3%) and second highest in North Auckland (33.3%). West Auckland shows a moderate employment growth ie 25.4% between 1971 and 1991. However, Central Auckland has shown negligible employment growth (1.8%) between 1971 and 1991. Employment changes in these areas have been proportionate to the population changes. In Central Auckland population growth was greater than the employment growth.

It is evident from table 6.4 that the share of population in the labour force in the Auckland Urban Area increased slightly between 1971 and 1981, but settled at 41% in 1991. Only 1.6% of employment change occurred in Central Auckland during 1971-91 which indicates the shift of employment in other parts within metropolitan areas such as North, West, and South zones of Auckland. This shift reflects the process of suburbanisation (outward migration of jobs) which has resulted in greater distances between jobs and residences and other community needs.

Table 6.4 EMPLOYMENT DISTRIBUTION IN FOUR ZONES 1971-91

Zones	1971		1981		1991		% Change 1971-1991	
	No	%	No	%	No	%	No	%
NORTH	42,710	15	64,539	19	81,735	21	39,025	33
WESTERN	34,477	13	51,177	15	64,188	17	22,002	48
CENTRAL	129,825	49	125,043	38	131,936	34	2,111	2
SOUTH	61,138	23	95,397	28	107,352	28	46,214	39
AVERAGE	**268,150**	**100**	**250,530**	**100**	**298,260**	**100**	**107,654**	**30**

Source: NZ Census of Population 1971, 1981, 1991.
Auckland Regional Planning Services 1971

6.7 DISTRIBUTION OF POPULATION AND JOBS

New Zealand cities like the U.S. and Australian cities, have a high job concentration and generally few residents in the CBD. European and Asian cities have a balance between central city jobs and residences. Auckland Central, which includes the CBD and inner residential areas, has some balance between central city jobs and residences. The proportion of jobs located in different parts of Auckland Urban Areas are shown in Table 6.5.

Table 6.5 DISTRIBUTION OF POPULATION DENSITIES AND JOBS 1991

Zones	Density of Pop. per hectare		Full Time Employment		Working Population (15-64)		Proportion of Jobs to Population (Ratio's)
	Overall	Net	No	%	No	%	
NORTH	7.5	45	62,060	16	111,591	20	1:.55
WESTERN	8.3	55	41,615	11	90,549	16	1:.46
CENTRAL (including CBD)	20	39	225,655	60	189,954	35	1:1.18
SOUTH	8.3	45	88,932	23	162,576	29	1:.55
TOTAL/ AVERAGE	**11**	**46**	**385,211**	**100**	**554,670**	**100**	**1: .69**

Source: NZ Census of Population 1971, 1981, 1991.
Auckland Regional Planning Services 1971

It is evident from Table 6.5 that the highest number of full time jobs are concentrated in the Central Auckland area, 60% compared with 35% of the working age population residing in that zone. The ratio of jobs to residents is highest in Central Auckland ie. 1.18 compared to 0.55 in the North, 0.46 in the West and 0.55 in the South urban areas of Auckland. The population to jobs ratios in all four urban areas of Auckland are more like central areas of European cities. One of the reasons for such population to jobs ratios is the multi-nuclei nature of Auckland.

6.8 PUBLIC TRANSPORT AND TRAVEL TO WORK

The higher than 30 persons per hectare and jobs corresponding to those densities in all parts of the city are significantly associated with more public transport passenger kilometres per person, high proportion of total passenger kms on public transport, greater public transport services provision per person, more annual trips per person and a higher proportion of workers using public transport. As already mentioned, higher densities are in each case associated with a greater proportion of people using foot and bicycle to work. The proportion of jobs in city centers is one of the key factors behind developing a vital public transport system. Similarly correlation with the number of

jobs in the city center and public transport do in fact show much greater significance. Concentration of jobs may be more important for the viability of public transport than density of jobs in the central city.

Tables 6.6 and 6.7 show that the majority of people use cars/trucks/vans as a mode of transport to get to work in 1981 and 1991 in Auckland. Private car use was a popular mode of transport in 1981 when more than 50% of population was using this mode to travel to work. During 1991 the use of private transport to get to work was even greater and more than 65% of the population was using this mode of transport. Public transport was a popular mode of transport for 16% to get to work in 1981 compared to 8% in 1991. Walking was a mode of transport for 9% of the population in 1981 compared to 6% in 1991. However, cycling was a static mode of transport to travel to work between 1981 and 1991. Central Auckland has the highest number of people using public transport as a mode of transport to get to their work places during 1981 and 1991. The trend of working from home has also increased during recent years because of new technologies and the availability of advanced tele- communication facilities. The proportion of the population who did not work increased from 6% in 1981 to 10% in 1991.

Private transport is gaining popularity in Auckland and more than 60% of the work force have been using this mode for travel to work. Cross commuting is one the biggest reasons behind the high use of private transport. People living in South or East Auckland are travelling to work in the North Shore or vice versa. Public transport mode has declined during the last decade from 13% to 12%, in spite of more centralised jobs in Central Auckland, although both density and centralisation appear to be clear factors which determine the viability of public transport and thus a less automobile dependent city. Low density Auckland urban area has comparatively less density of population to support very expensive public transport mode compared to European cities.

Table: 6.6 TRAVEL TO WORK IN FOUR ZONES OF AUCKLAND 1981

Mode of Transport	Central Auckland		South Auckland		North Auckland		Western Auckland	
	No	%	No	%	No	%	No	%
Did not work	7,191	6	6,042	6	2,325	4	2,415	5
Public transport	20,253	16	8,883	9	8,973	14	5,565	11
Train	1,107	1	1,896	2	24	0	840	2
Drove car/ truck/van	62,037	50	53,466	55	36,354	55	28,857	56
Passenger in car/truck/or bus	11,301	9	11,097	11	7,230	12	5,913	11
Bicycle	2,988	2	2,277	2	1,038	2	846	2
Motor/ power cycle	2,829	2	2,280	2	1,875	3	1,755	3
Walked	11,424	9	6,498	7	3,522	5	2,625	5
Other means	690	1	342	0	921	1	177	0
Work at home	4,308	3	3,000	3	3,087	5	2,499	5
Not specified	1,191	1	816	1	369	1	372	1
TOTAL	**125,325**	**100**	**96,594**	**100**	**65,715**	**100**	**51,864**	**100**

Source: New Zealand Census of Population 1981

Table: 6.7 TRAVEL TO WORK IN FOUR ZONES OF AUCKLAND 1991

Mode of Transport	Central Auckland		South Auckland		North Auckland		Western Auckland	
	No	%	No	%	No	%	No	%
Did not work	11,355	9	9,711	9	8,820	11	6,243	10
Public transport	10,494	8	4,650	5	5,013	6	3,219	5
Train	324	0	789	1	15	0	372	1
Drove car/ truck/van	52,920	62	40,596	65	79,011	63	66,798	65
Passenger in car/truck/or bus	7,803	6	8,031	8	5,223	6	4,593	7
Bicycle	2,598	2	1,974	2	1,311	2	855	1
Motor/ power cycle	1,116	1	894	1	828	1	738	1
Walked	7,122	6	4,059	4	2,997	4	2,028	3
Other means	1,011	1	525	1	3,813	2	279	0
Work at home	5,262	4	3,429	3	3,813	5	2,805	4
Not specified	2,154	2	1,674	2	882	1	915	1
TOTAL	**128,244**	**100**	**102,528**	**100**	**83,364**	**100**	**62,646**	**100**

Source: New Zealand Census of Population 1991

6.9 TRIP MAKING BEHAVIOUR

The number of dwellings in the Auckland urban area increased by 11% between 1986 and 1991 while the number of jobs decreased by 3%. Car ownership increased from 1.4 to 1.5 per household. The number of vehicle trips in Auckland increased by 77% between 1963 and 1973 and 64% between 1973 and 1992. Person trips increased 67% between 1963 and 1973 and 34% between 1973 and 1992. The number of trips per person has also increased quite rapidly from 1.2 per day in 1963 and 1.4 per day in 1973 to 2 per day in 1991 (ALTS, 1994). This increase in trip making is not only due to the increase in car ownership but also as a result of short distance trips.

The results of a survey results conducted by the Regional Council in 1963 was used to update the Comprehensive Transport Study (1973). It has show that the population has been increasing at a rate of 1.2% per annum (pa) since 1973, and trip making has been increasing at 1.6% (pa). Vehicle trips have been increasing at more than twice the rate of the growth in population. According to the Census, work trips made by public transport has declined from 15% in 1986 to 8% in 1991 and trips to work by car increased from approximately 55% in 1986 to approximately 65% in 1991.

The results of the ATM (Auckland Transport Management) Project Home Interview Surveys compared with similar surveys carried out in 1973 for the Auckland Comprehensive Transport Study are shown in Table 6.8. The Table indicates some significant changes between 1963 and 1992, regarding person trips, vehicle trips, population, vehicles and trips per person. It has been witnessed that 67% of growth took place in trip making per day between 1963 and 1973 . More than 34% of growth took place in trip making per day between 1973 and 1992. The number of vehicles increased from 113,320 to 289,290 during 1963 to 1973 and from 289290 to 468,670 between 1973 and 1992 at a rate of 155.3% and 62% increase respectively. Vehicle trips also increased at a high rate ie, 77% between 1963 and 1973 and 64% between 1973 and 1992.

The Table shows that person /vehicle trips declined from 1.8 in 1963 to 1.4 in 1992 which may encourage some policies of ride sharing. Person trips per day has increased because of flexible working hours, part time jobs and due to more use of vehicles for personal trips during the day.

Table 6.8 **TRIP MAKING CHANGES IN AUCKLAND 1963-1992**

Trip Making	1963	1973	1993	% Growth Change 1963-1993	
				1963-73	1973-93
Trips Per Person	1,048,207	1,746,505	2,344,114	67	34
Vehicles Trips	578,766	1,025,081	1,682,116	77	64
Population	491,636	710,741	875,490	45	23
Vehicles	113,320	289,290	468,670	155	62
Trips/Person	2.13	2.46	2.68	15.3	9
Trips/Vehicle	5.1	3.5	3.6	--	--
Person/ Vehicle Trips	1.8	1.7	1.4	--	--

Source: Auckland Regional Policy Statement 1994

6.10 CAR OWNERSHIP PER HOUSEHOLD

The number of cars per household gives significant information regarding changing trends of travel to work and for other activities. Table 6.9 shows that there is a 29.3% increase in the total number of households having cars. The number of households having no car dropped from 44,561 to 40,065 between 1973 and 1991. This drop contributes -1.81% indicating more household shift from no car to one or more cars. This change in car ownership resulted in an increase in travelling by car, requirement of more parking spaces and increased consumption of fossil fuel and environmental depletion. The trend of having two cars also increased in the last two decades which shows a 41.53% increase. The trend of having three and above cars increased in New Zealand in the last twenty years. There were 8% of households who own 3 + cars in 1973 compared to 14% in 1991. However, the trend of having 3 + cars contributed 57% change between 1973 and 1991.

Table 6.9 NUMBER OF CARS PER HOUSEHOLD 1973-1991

Number of Cars	1973		1986		1991		No & % Change 1973-91	
	No	%	No	%	No	%	No	%
0 Car	44,561	20	40,488	14	40,065	12	-4,496	-2
1 Car	103,134	46	129,078	45	134,706	42	31,572	23
2 Cars	59,605	26	84,375	29	101,952	32	42,347	42
3+ Cars	18,801	8	34,533	12	43,257	14	24,456	57
TOTAL	**226,101**	**100**	**288,474**	**100**	**319,980**	**100**	**93,879**	**29**

Source: 1973 Auckland Comprehensive Study 1973, New Zealand Census of Population and Dwellings, 1986 and 1991.

6.11 CONCLUSION

The optimum density is generally in the range of 30-35 dwellings per hectare based on an average of five bedrooms per dwelling required to achieve the high level densities to reduce energy efficiency (Rydin, 1992). The main exception is for housing for district heating or for combined heat and power. Although optimal density levels are difficult to measure with any certainty, feasibility studies for combined heat and power have mostly favoured dwelling densities of 44 or more dwellings per hectare (Owens, 1991).

It is very difficult to achieve such densities in most of the cities of USA, Australia and New Zealand. The number of dwellings per hectare in Auckland is very low, compared with the optimal densities suggested by Owen (1991) and Rydin (1992). However, increased density could be expected from inward and infill land use development and by the development of high density multi-family dwellings along major public transport corridors.

A density of 30 to 40 persons per hectare as suggested by Newman and Kenworthy (1989) can be achieved by combining 60% two to six storey apartments, 20% town houses and 10% single family cluster homes, with 30% developable area devoted to open space and recreation. It is also possible

to achieve densities above 30 persons per hectare by developing two storey apartment buildings and two storey town houses with a share active open spaces and passive open spaces. However, with low levels of dwelling occupancy typical of Auckland, it is unlikely that such densities can be reached without some component of medium to high rise apartments. Even then, there is a question over their social acceptability.

The share of population in the labour force in the Auckland Urban Area increased slightly between 1971 and 1981, but settled at 41% in 1991. Only 1.6% of employment change occurred in Central Auckland during 1971-91 which indicates the shift of employment in other zones within metropolitan areas such as North, West, and South of Auckland. This shift reflects greater distances between jobs and residences and other community services. The ratio of jobs to residents is highest in Central Auckland ie. 1.18 compared to 0.55 in the North, 0.46 in the West and 0.55 in the South urban areas of Auckland.

Private transport is used by more than 60% of the work force in Auckland. Cross-commuting is one of the reasons behind the high use of private transport. Increasingly, people living in South or East Auckland are travelling to work in the North Shore or vice versa. Public transport use declined between 1981 and 1991, from 13% to 12%. Auckland urban area has a less density of population compared with European cities which support successful public transport systems. Person trips per day have increased because of flexible working hours, part time jobs and due to more use of vehicles for personal trips during the day.

Other contributing factors include new living and working trends, and high and increasing car ownership. These trends pose a threat by way of environmental depletion and consumption of natural and physical resources. Therefore, policies supporting public transport may have to adopted and policies favouring private transport given less weight in transport planning.

CHAPTER 7
EVALUATION OF TRANSPORT PLANNING IN AUCKLAND

7.1 BACKGROUND

Modern transport planning in Auckland started in the 1950's, and followed established transportation planning approaches and principles. The Master Transport Plan (1954-55) was the first comprehensive study of its kind for Auckland. This included a complete survey of the metropolitan area and regional traffic problems and provided a detailed report to guide future transport patterns for the entire region. The recommendations emphasised the construction of motorways and maintenance of existing arterial roads. They included proposals for electrification and underground extension of the suburban railway system, which were, however, beyond the financial capability of Auckland Regional Authority and therefore abandoned. Government and local authorities favoured construction of a motorways system and subsequently initiated public investment in urban motorways.

The Comprehensive Transportation Study conducted between 1963 and 1965 was intended to develop a comprehensive programme for motorway construction, highway improvements and parking facilities. Like the Master Transport Plan, it encouraged more road construction. A number of supplementary transport studies were undertaken between the Comprehensive Transport Study 1963-65 and the next comprehensive exercise, the Auckland Comprehensive Transportation Study, undertaken between 1973 and 1975.

The Auckland Comprehensive Transportation Study considered issues relating to urban expansion against a background of the depletion and rising cost of the world's fuel resources and the high and rising costs of urban transport needs. The comprehensive nature of this study demanded detailed evaluation of alternative land use/ transportation plans. The study encouraged decentralisation by calling for sub-centers at high density nodes of activity. This was intended to reduce congestion on the transport corridors and pressure on parking facilities in central Auckland. This study represented a change in focus. Previous studies sought to meet forecast demand for travel with maximum freedom of choice for the trip-maker, but the Auckland Transportation Study proposal considered land use patterns which would reduce the relative demand for transport.

Between 1975 and 1988, various supplementary transport studies were undertaken. Their emphasis was once again on the construction of motorways, including consideration of a second Harbour Bridge, and highway improvement in the Auckland region. They also encouraged decentralisation of the central business district and suburban development. Those transport studies were basically an extension of the Auckland Comprehensive Transportation Study 1973-75.

The Proposed Regional Policy Statement, 1994, sets out strategies for regional development, transportation and energy consumption. These strategies are intended to ensure that development in the region is managed in a manner which protects natural values and improves urban efficiency, while maintaining opportunities for social and economic activities. The Auckland Regional Policy Statement proposed a major shift for the future development of Auckland, providing a broad framework for the sustainable use of the natural and physical resources of the Region.

The Auckland Regional Land Transport Strategy 1994 was proposed under the provisions of the Transit New Zealand Act 1989 as amended in June 1992. The overall objective of the strategy is to provide a framework for the development and management of a safe, efficient and effective transport system which contributes to sustainable management of natural and physical resources of the Auckland region and the well being of the community.

The Auckland Strategic Planning Model (ASP) is the strategic policy and planning component of the Auckland Transport Model (ATM). ASP enables a wide range of infrastructure and development issues and options for the Region to be considered before analysis of detailed transportation options and policies is undertaken through ATM. So far, four development policy options have been proposed in ASP, which provide a basis for examining urban containment and intensification.

This chapter examines these various plans in the context of sustainability criteria to identify the extent to which each has contributed to, or detracted from, the sustainable development of the Auckland metropolitan area. This is done by relating their various goals and policies to the criteria of urban sustainability identified in Chapter 4. This comparison describes policies accordingly whether they are consistent or inconsistent with the sustainable criteria. Policies which have no effect on sustainability criteria are identified as 'not applicable (na)'.

7.2 METHODOLOGY

The methods for achieving sustainability (summarised in Chapter 4) are treated as the criteria against which transport policy options are judged to determine how far each of the plans contributes to (or detracts from) urban sustainability.

This has been done by assessing relationships between each policy option and sustainability methods or criteria. Where the two are completely incompatible, the policy is judged to be inconsistent (ic) with the criterion. Where the policy is likely to reinforce or support sustainability as denoted by that criterion, it is judged to be consistent (**C**). In some areas where the impact of the policy is judged to have no impact on its sustainability effect, these instances are considered as not-applicable (na).

All plans have been judged with reference to the literature discussion in Chapters 2/3 and 4. In reaching some overall judgement on the relative contributions towards sustainability, the ratio of consistent to inconsistent methods has been calculated for each of the plans considered.

7.3 THE MASTER TRANSPORTATION PLAN 1954-55

This Plan was produced on the basis of forecasts which assumed that the past history of traffic growth on a given road would continue subject to adjustments made according to the relative importance of the road within the whole network. No formal transportation modelling was undertaken. This "Predictive Model" used, although simplistic, aimed at greater efficiency of regional transport in the context of rapid growth through development of the motorway, arterial road system, and more efficient bus-based public transport. The resulting "structure planning" approach supported low density development and aimed to develop both the road network and public transport to sustain this.

The motorway and arterial road system fostered urban sprawl in the Auckland Region. The Harbour Bridge, state highway and motorway proposals opened up new avenues for growth in all parts and on the main fringe of the city, especially in South and North Auckland. The proposal for express buses with stops on motorways was intended to connect more distant suburbs with Central Auckland and other active parts of the city. These transportation proposals allowed low to medium income people to move out from the centre in search of cheap land and housing. Incorporating measures to increase accessibility, encouraged low density development away from the traditional center.

Table 7.1 shows the overall goal, study objectives and policy recommendations of the Master Transportation Plan. The plan encouraged highway and consequently induced motorised traffic and urban development away from the traditional city centre.

Analysis of the plans and policies in the Master Transportation Plan against the criteria for sustainability suggests six consistent and twenty six inconsistent policies (Table 7.2). The polices which are consistent include provision for public transport links in sub-centers, better traffic management, and a safe and efficient public transport system. The plan has a few inconsistent policies relating to land use, urban form and density of population.

The first policy option is almost fully inconsistent, although the highway and ring road construction envisaged could be seen to contribute to the potential for public transport and, perhaps alternative transport modes, such as cycleways. The second policy option emerges as inconsistent on the ground of impact on land use and urban forms. Only the provision made under policy option four (express busways) offers some potential for sustainability. It provides for an effective public transport system, although it is not an option which might contribute to a benefit for a compact city strategy.

The Master Transportation Plan fostered car oriented land use and was oriented to urban expansion. No policies deal with the compactness of the city, conversion of residential areas to high density along the major corridors, encouragement of mixed land use, urban design or the behavioural changes associated with sustainable urban development. Instead, a structure planning approach was adopted to meet the transport needs of an expanding city. The plan provided for infrastructure based on predicted need according to a vision of planned outward growth.

Overall, the policies proposed in the Master Transportation Plan 1954-55 are inconsistent with the sustainability criteria. Only two policies, those dealing with public transport and use of express buses on motorways, are consistent.

Table 7.1
THE MASTER TRANSPORTATION PLAN 1954-55

GOAL	OBJECTIVES	POLICY RECOMMENDATIONS
To undertake a survey of the entire Metropolitan Area's transportation and traffic problems and prepare a detailed report and Master Transport Plan.	1. To conduct a transportation survey and build a data base. 2. To identify traffic problems and prepare reports after proper analysis. 3. To prepare Master Transportation Plan.	1. Construction of 33.7 miles of urban motorways, including a ring road around the central business district. 2. Upgrade existing arterial roads and integrate with the motorway system. 3. Abandon proposals for electrification and underground extension of the suburban railway system. 4. Use of express buses with stops on motorways.

TABLE 7.2 **MAIN POLICY OPTIONS UNDER THE MASTER TRANSPORTATION PLAN 1954-55 VS SUSTAINABILITY CRITERIA**

SUSTAINABILITY CRITERIA	Construction of highways, including ring road around the CBD	Upgradation of existing arterial roads and link with motorway system	Abandonment of proposal for electrification and underground extension of the suburban railway system	The use of express buses with stops on motorways
Land use, Urban Form and Density Control				
1. More intensive land uses by creating a compact city.	ic	ic	ic	na
2. High densities along and within the major corridors allowing mixed use and dual occupancy housing.	ic	ic	ic	C
3. Multiple family development in transit corridors.	ic	ic	ic	ic
4. More centralised land use for more walking and cycling	ic	ic	ic	ic
5. Controlling new development in urban areas by balancing jobs and population required to support it.	ic	ic	ic	na
6. Integrated new development for energy conservation and efficiency.	ic	ic	ic	na
Environment, Energy and Transport Viability				
1. Alternative modes of transport such as ride sharing and park and ride.	na	na	ic	na
2. Safe and efficient public transport systems. bicycle routes.	C	na	na	C
3. Pedestrian connections in the city center and sub-centers.	na	na	ic	na
4. Mass transit programs in high density corridors.	na	na	ic	C
5. High occupancy transport modes.	na	na	ic	C
6. Relating future developable land and land transport needs.	na	na	na	na
7. Measuring energy use and emission.	na	na	na	na
8. Increasing overheads for private cars within Central Business District.	na	na	na	na
9. Balancing transport, socio-economic, and environmental needs through regulatory measures.	na	na	na	na
Behavioural Changes And Regulatory Measures				
1. Encouraging development in the CBD to achieve urban containment.	na	na	na	C
2. Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	na	na	na	na
3. Regulating vehicle numbers	na	na	na	na
4. Rule on vehicle use	na	na	na	na
Urban Design				
1. Achieve density between 20 and 40 persons per hectare by designing mixed use development.	na	na	na	ic
2. High rise construction in the CBD in urban areas connected by pedestrian tubes on various levels.	na	na	na	ic
3. Good orientation and layout pattern for energy conservation.	na	na	na	na
SUMMARY TOTAL				
CONSISTENT (C) 6	1	0	0	5
IN-CONSISTENT (ic) 27	6	6	10	5
NOT APPLICABLE (na) 55	15	16	12	12
RATIO C : IC .22	.17	0:6	0:10	1

7.4 THE COMPREHENSIVE TRANSPORTATION STUDY 1963-65

The Auckland Regional Planning Authority commissioned de Leuw Cather and Co., a US-based transportation and engineering consultancy, to undertake a Comprehensive Transportation Study in 1963. The overall objective of the study was to develop a plan and programme for motorway construction, highway improvement and parking facilities for the Auckland region. It was thus intended to build on the direction set in the Master Transportation Plan. The overall goal, scope of the study and policy recommendations are shown in Table 7.3.

In 1964 a regional transit study was undertaken by Leuw Cather and Co. The study collected basic travel data to evaluate two alternative public transport plans for Auckland. The purpose and scope of the plans were to review existing public transport systems, routes, schedules, loading, equipment and fares, and predicted future public transport travel demand for the two alternative systems.

The study determined existing travel patterns throughout the region and applied growth factors based upon projected population and land use to forecast future travel needs. The plan called for an extension of the motorway network and arterial roads, expressways, and construction of a second harbour bridge. This focus on an efficient road network for the movement of people and goods was justified in terms of the development of trade and commerce in the region. While the recommendations appear consistent with sustainability, they were very expensive to implement.

Public transport was given more consideration in the Plan than in the Master Transportation Plan 1954-55. The Comprehensive Transportation Plan supported the extension of the bus and a rapid rail transit system. It called for electrification of the existing southern and western lines to Puhinui and New Lynn respectively and retention of radial bus routes in the corridors. The plan also recommended construction of rapid rail transit extension under Custom and Queen Streets to the Civic Centre. The policy recommendations regarding transport viability are consistent with the criteria for sustainability. However, policies for sustainable land use, urban form and density of population are inconsistent insofar as they supported decentralised development. Promotion of motorways and arterial roads also supported the phenomenon of urban sprawl in the Auckland region. Otherwise, most of the policies included in the Comprehensive Transport Study 1963-65 are irrelevant to the sustainability criteria.

Table 7.4 shows that seven policy recommendations are consistent and 18 policy options inconsistent with the criteria of sustainability. The Comprehensive Transportation Plan (1963-65) has less conflicting policies than the Master Transportation Plan (1954). Once again, the land use implications are totally contrary to sustainability. However, the plans for a transit system and public transport denote a slight shift towards sustainability, although the transit policy option was not implemented in practice.

The second policy supports highway extension beyond 1986, including the construction of a second harbour bridge and additional expressways. The beginning of the undermining of the CBD as a focus of employment and city administration which appeared in the Master Transport Plan 1954-55 was continued in the Comprehensive Transportation Study 1963-65. Only the introduction of the feeder system to serve the transit rail differentiates the direction of the 1963-65 study from that of 1954-55.

Overall, the plan does not cover sufficient parameters to be consistent with the promotion of sustainable land use and transport. The development of new feeder bus networks to serve the rapid rail transit links, and development of radial bus routes in the corridor are consistent with a sustainable public transport system. However, the policy options for extension of the bus and rapid rail transit system by electrification under Custom and Queen Streets to the Civic Centre were never implemented.

TABLE 7.3
THE COMPREHENSIVE TRANSPORT STUDY 1963-65

GOAL	OBJECTIVES	POLICY RECOMMENDATIONS
To develop a plan and programme for motorway construction, highway improvements and parking facilities for the Auckland region.	1. To conduct an origin and destination survey to determine existing vehicular travel patterns throughout the region. These included a home interview survey, truck and taxi surveys, and external cordon survey. 2. To determine growth factors based on projected population and land use within the region to be used as a basis for forecasting future vehicular travel need. 3. To evaluate alternative motorway and arterial road networks.	1. Construct 90 miles of motorway by 1986, 25 mile of arterial roads and 57 miles of road widening. 2. Provide for extensions beyond 1986, including second harbour bridge and additional expressways. 3. Extend of the bus and rapid rail transit system by electrification of the southern and western lines to Puhinui and New Lynn and construction of underground extension under Custom and Queen Streets to the Civic Center.
Note: The Comprehensive Transport Plan of 1965 was adopted by Auckland Regional Authority and the National Roads Board, and formed the basis for motorway and arterial road construction and improvement over the next decade.	4. To develop a staged programme for implementation, including preliminary cost estimates. 5. To review the existing public transport system, route schedules, loading, equipment and fares. 6. To predict future public transport demand.	4. Provide a feeder bus network to serve the rail. 5. Retain a radial bus routes in the remaining corridors.

TABLE 7.4 MAIN POLICY OPTIONS UNDER THE COMPREHENSIVE TRANSPORTATION STUDY 1963-65 VS SUSTAINABILITY CRITERIA

KEY SUSTAINABILITY CRITERIA	Construction of motorways and arterial roads	Extention beyound 1986, including second harbour bridge and additional expressways	Extension of the bus & rapid rail transit system including extension of rail system under Custom & Queen St. to the Civic Center	Providing a feeder bus network to serve the transit rail and retaining a radial bus routes in the remaining corridors
Land use, Urban Form and Density Control				
1. More intensive land uses by creating a compact city.	ic	ic	na	na
2. High densities along and within the major corridors allowing mixed use and dual occupancy housing.	ic	ic	na	na
3. Multiple family development in transit corridors.	ic	ic	na	na
4. More centralised land use to encourage walking and cycling	ic	ic	na	na
5. Controlling new development in urban areas by balancing jobs and population required to it.	ic	ic	na	na
6. Integrated new development for energy conservation and efficiency.	ic	ic	na	na
Environment, Energy and Transport Viability				
1. Alternative modes of transport such as ride sharing and park and ride.	na	ic	na	C
2. Safe and efficient public transport systems, bicycle routes.	na	ic	C	C
3. Pedestrian connections in the city center and sub-centers.	na	na	na	na
4. Mass transit programs in high density corridors.	na	na	C	C
5. High occupancy transport modes.	na	ic	C	C
5. Relating future developable land and land transport needs.	na	na	na	na
7. Measuring energy use and emission.	na	na	na	na
3. Increasing overheads for private cars within Central Business District.	na	na	na	na
. Balancing transport socio-economic, and environmental needs through regulatory measures.	na	na	na	na
lehavioural Changes And legulatory Measures				
Encouraging development in the CBD to achieve urban containment.	na	ic	na	na
Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	na	ic	na	na
Regulating vehicle numbers.	na	na	na	na
Rules on vehicle use	na	na	na	na
rchitecture Designs				
Achieve density between 20 and 40 persons per hectare by designing mixed use development.	na	ic	na	na
High rise construction in the CBD in urban areas connected by pedestrian tubes on various levels.	na	ic	na	na
Good orientation and layout pattern for energy conservation.	na	na	na	na
SUMMARY TOTAL				
NSISTENT (C) 7	**0**	**0**	**3**	**4**
:ONSISTENT (ic) 19	**6**	**13**	**0**	**0**
T APPLICABLE (na) 62	**16**	**9**	**19**	**18**
ΠO C:IC .36	**0:6**	**0:13**	**.15**	**4:0**

7.5 EXTENSION OF COMPREHENSIVE TRANSPORT STUDY 1963-1965

Between 1965 and 1973, a series of study updates were carried out on the basis of the survey results from 1964. While, these studies maintained support for alternative means of transport and encouragement of public transport, their information base and assumptions reflected the preceding studies in their focus on development of the motorway system. The studies carried out between 1965 and 1973 are summarised below.

7.5.1 South Auckland Traffic Study 1967-70

This study was carried out under the auspices of a Technical Advisory Committee comprising representatives of the Ministry of Works and Development, Ministry of Transport, Auckland Regional Authority and all territorial local authorities in the South Auckland area. The aim was to design and programme a roading network for South Auckland at a more detailed level than contained in the de Leuw Cather report.

The land use projections for 1986 made in 1963 were maintained, but there a redistribution of activities within the South Auckland area and more detailed road networks were prepared. The trip generation rates and the modal split determined by deLeuw Cather were also retained, so the study produced new trip distributions and assignments to three test networks, and then to a final network recommended in the report of the Technical Advisory Committee published in July 1970. The new network was then incorporated in the Regional Planning Schemes and has been used as a guide to road planning by local authorities in the South Auckland area.

7.5.2 Auckland International Airport Transportation Study 1967-68

It was felt after the de Leuw Cather study that the International Airport had particular trip generation characteristics which could not be taken into account in comprehensive studies. Therefore, a special airport study was carried out in 1967 to develop models for forecasting traffic separation, parking demand and trip distribution to assist designing future roading and parking requirements for the airport itself.

A survey was conducted of persons leaving the airport and by separating employee and commercial trips from those associated with aircraft operation.. This provided a basis for simple models to forecast flight generated trips and parking demand related to air passenger movement. The models were checked with fresh data in 1973 and found to be still valid, and were used to predict airport trips for the Comprehensive Transport Study, 1973.

7.5.3 Regional Planning Scheme 1966-1974

The projections of traffic flows by de Leuw Cather were assessed and a number of manual re-assignments were made to test alternatives for the preparation of the Regional Planning Scheme road network between 1966 and 1969. Some modifications were made to the 1965 Comprehensive Transportation Plan and Regional Transit Plan. Following receipt of objections to the Regional Planning Scheme after its public notification in 1969, further modifications were made. These included incorporation of the recommended road network from the South Auckland Study. Finally, prior to the scheme becoming operative in June 1974, the Regional Transit Plan and a section of the South-East Motorway were deleted awaiting further investigation by Government.

7.5.4 Auckland Rapid Rail Study 1970-72

Following publication of de Leuw Cather's Regional Transit Plan in 1965 the Government set up a working party in 1968 "to investigate and make recommendations on the most desirable route for a rapid rail transit system in the Auckland Region." The Working Party reported in May 1969. A Steering Committee was then set up to investigate the recommendations of the Working Party. One recommendation was that a cost/benefit study of the proposed system be carried out. This led to the Auckland Rapid Rail Study being undertaken by a joint Ministry of Works, Auckland City Council and Auckland Regional Authority team in an endeavour to determine future patronage estimates.

The study team re-analysed the original home interview data collected in the 1963 origin-destination surveys and calibrated a set of trip generation and distribution models. While attempts to estimate future public transport patronage were not successful for the purpose of the cost/benefit study, traffic assignments were obtained for 1976 and 1996 road networks and these

have since been used to a limited extent as a guide to longer term planning. However, this study did not result in any amendments to the 1965 Comprehensive Transportation Plan or the Regional Planning Scheme.

7.5.5 North Shore Transportation Study 1972-73

After the decision of the Government to locate a second Auckland university in Albany, a Steering Committee was set up in July 1971 to prepare a development plan for the Albany Basin. This committee established a Working Party comprising officers of the Waitemata County Council, Ministry of Works and Development and Auckland Regional Authority. In April 1972 it commissioned the North Shore Transportation Study to evaluate a number of alternative land use/transportation plans for Albany Basin.

Time did not permit a detailed study nor the development of new transportation models, so the Auckland Rapid Rail Study models developed from the 1963 data were used with new regional land use forecasts for the years 1986 and 1999. The study methodology adopted did not provide a satisfactory means of investigating alternative cross-harbour facilities but it did enable an evaluation to be made of alternative roading networks within the Albany Basin in conjunction with Concept Plan and land use patterns. A report was prepared in May 1973 which stressed the need to consider the Albany development and the North Shore as a whole in the wider context of regional development and the study was then abandoned in favour of the Comprehensive Transportation Study Review.

7.5.6 Auckland Rapid Transit Study 1973-74

A Cabinet subcommittee on Auckland Rapid Transit was established by the Government in February 1973. In March of that year, the sub-committee received an appraisal from a committee for the Auckland Rapid Rail Study of 1970 to 1972.

This led to a Cabinet decision in July 1973 to proceed with the first stage of a rapid transit scheme for Auckland (in the Southern corridor) and a directorate and project team was set up to investigate and carry out preliminary design.

The directorate reported to Government in September 1974 with recommendations that Stage 1 of the scheme be constructed in two phases. The first phase would comprise the whole of the Southern corridor. The city underground loop from Auckland Station to the Civic Center to Newmarket was recommended as the second phase. The directorate also recommended that an Eastern loop through Orakei and Panmure should be included in stage 1.

No up-dated travel information was collected for this study, which used data collected for the 1963-65 Comprehensive Study. Estimates of patronage were based on an analysis of work and non-work journeys of the future population in the Southern corridor. The study was oriented more towards the design of a system rather than a review of the transportation needs of the Southern corridor.

7.6 AUCKLAND COMPREHENSIVE TRANSPORTATION STUDY 1973-75

The Auckland Comprehensive Transport Study was authorised by the Auckland Regional Authority in April 1970. A Technical Advisory Committee was established in December 1971 to advise on content and methods to be used in the study. The study itself commenced in March 1973 and was conducted by staff of the Authority's Planning Division with assistance from the Ministry of Works and Development.

In the first stage of the study, land use plans for the longer term evaluation were derived from alternative growth strategies formulated in the Auckland Regional Authority's Growth Alternatives Study. The Transportation Study identified significant factors in land use distribution which could be changed to modify travel demand and measured the response to alternative transport policies. This was done by comparing the size and pattern of demand established by each alternative growth strategy and by comparing the cost and performance of each transport network option in meeting this demand. This comparison identified directions in which changes should be made to the alternatives as tested, in order to achieve an efficient use of the land use/transportation plan.

The analytical stage of the transportation planning process included collection of information on the existing transportation system, land use characteristics, and travel patterns of the study area to establish a base for future travel prediction. The next stage covered data analysis and development of Transportation Models. In this step, three inventories of network, land use and travel data were brought together to establish relationships among them. The third step was the prediction of future travel. This required an inventory of the land use data and network characteristics for each of the future development options and transport policies. From a transportation point of view, alternative transport policies were evolved against criteria primarily concerned with the cost and efficiency of the transport networks. The final step was the recommendation of a preferred long-term land use/transportation strategy.

The emphasis in the Auckland Comprehensive Transportation Study 1973-75 differed from previous studies in some way, as this study encouraged decentralisation of jobs from the Isthmus for optimisation of the transportation system. However, it retained the flow of growth of travel in the major radial corridor. Policies Two and Three in the Auckland Comprehensive Transportation Study 1973-75 emphasised alternative growth options for future development because of a growing concern for the environmental and social problems of urban expansion, the depletion and rising costs of the world's fuel

resources and the high and rising costs of urban transport provision. The comprehensive nature of this study demanded new methodology and more advanced analytical techniques for the detailed evaluation of alternative land use and transportation plans.

The Master Transportation Study (1955) and Auckland Comprehensive Study (1963-65) were confined to evaluation of a limited number of land use or network options leading to publication of a recommended master plan. The emphasis in the Auckland Comprehensive Transport Plan 1973-75 was on implications of a wider range of possibilities and the adoption of a transportation plan which was as flexible as possible to provide for future growth (Table 7.5).

Policy options in the 1973-75 Auckland Comprehensive Transportation Study supported decentralisation of jobs from Central Auckland and restrained land use growth in the major radial corridors to optimise the transportation system (Table 7.6). Only six of the policy options advanced for transport viability are consistent with the criteria for sustainabilty. By contrast, the plan has twenty three inconsistent policy options and thirty seven policies which are not applicable.

Decentralisation of jobs from Central Auckland to other zones of Auckland was one of the key criteria proposed for control of private vehicles entering Central Auckland and for fuel conservation. The only difference between the policy recommendation regarding decentralisation of jobs in the plan and the proposed criteria is that the latter would encourage decentralisation of the Central area by developing sub-centers at high density nodes of activity, where walking and cycling may become more viable modes of transportation. By contrast, the plan attempts to optimise the use of the existing transport system and will result in less congestion on the transport corridors and greater parking facilities in Central Auckland. The policies for sustainability support high density multiple use and mixed land use activity along the existing transport corridor for efficient and door step public transport. The policy options in the plan for investment in public transport which seek to defer the need for investment in new roading facilities are also consistent with sustainable criteria.

TABLE 7.5

THE AUCKLAND COMPREHENSIVE TRANSPORTATION STUDY 1973-75

GOAL	OBJECTIVES	POLICY RECOMMENDATIONS
To enable a landuse/transportation planning process to be established capable of testing and review the alternative forms of urban growth. To assess alternative forms of urban growth. To develop and review the transportation works programme.	1. To build a data base to review transportation model. 2. To review the analytical procedures in order to improve the quality of the transportation model. 3. To evaluate the transportation implication of future alternative growth forms for the Auckland region, and guide the transportation components of the growth alternative study. 4. To evaluate alternative transport networks, including alternative public transport system, for the Auckland region. 5. Arising out of these evaluations to review current implementation plans for the road network and public transport proposal. 6. To obtain traffic assignments in sufficient detail for geometric design purposes.	1. Encourage decentralisation of jobs from the Isthmus for optimisation of the transportation system and to restrain growth of travel in the major redial corridors. 2. Increase the existing capacity of major radial corridors by greater investment in public transport to defer the need for investment in new roading facilities. 3. Shift emphasis in roading investment away from the traditional radial corridors to areas where such investment would be consistent with promoting a policy of decentralisation. NOTE: It was noted that policies to restrain use of motor vehicles such as road pricing, high parking costs, and incentives for car pooling were not investigated.

TABLE 7.6 MAIN POLICY OPTIONS UNDER THE AUCKLAND COMPREHENSIVE TRANSPORTATION STUDY 1973-75 VS SUSTAINABILITY CRITERIA

SUSTAINABILITY CRITERIA	**Encourage decentralisation of jobs from the Isthmus for optimisation of the transportation system and to restrained the growth of travel in the major radial corridors**	**Increased the existing capacity of major radial corridors by greater investment in public transport to defer the need for investment in new roading facilities**	**Shift emphasis in roading investment away from the traditional radial corridors to areas where such investment would be consistent with promoting a policy of decentralisation**
Land use, Urban Form and Density Control			
1. More intensive land uses by creating a compact city.	ic	na	ic
2. High densities along and within the major corridors allowing mixed use and dual occupancy housing.	C	na	ic
3. Multiple family development in transit corridors.	C	na	ic
4. More centralised land use to encourage walking and cycling	ic	na	ic
5. Controlling new development in urban areas by balancing jobs and population required to support it.	ic	na	na
6. Integrated new development for energy conservation and efficiency.	ic	na	na
Environment, Energy and Transport Viability			
1. Alternative modes of transport such as ride sharing and park and ride.	na	na	na
2. Safe and efficient public transport systems, bicycle routes.	C	na	na
3. Pedestrians connection in the city center and sub-centers.	na	na	na
4. Mass transit programs in high density corridors.	C	ic	ic
5. High occupancy transport modes.	C	ic	ic
6. Relating future developable land and land transport needs.	na	na	na
7. Measuring energy use and emission.	na	na	na
8. Increasing overheads for private cars within Central Business District.	na	na	na
9. Balancing transport, socio-economic, and environmental needs through regulatory measures.	na	na	na
Behavioural Changes And Regulatory Measures			
1. Encourage development in the CBD to achieve urban containment.	ic	ic	ic
2. Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	ic	ic	ic
3. Regulating vehicle numbers.	na	na	na
4. Rules on vehicle use.	na	na	na
Urban Designs			
1. Achieve density between 20 and 40 persons per hectare by designing mixed use development.	ic	ic	ic
2. High rise construction in the CBD in urban areas connected by pedestrian tubes on various levels.	ic	na	na
3. Good orientation and layout pattern for energy conservation.	na	na	na
SUMMARY TOTAL			
ONSISTENT (C) 5	**5**	**0**	**0**
NCONSISTENT (ic) 23	**8**	**5**	**10**
OT APPLICABLE (na) 38	**9**	**17**	**12**
ATION C:IC .21	**.62**	**0:5**	**0:10**

7.7 THE PROPOSED AUCKLAND REGIONAL POLICY STATEMENT 1994

The Proposed Auckland Regional Policy Statement (ARPS) was prepared in 1994 under the Resource Management Act 1991. It gives a broad outline of how the natural and physical resources of the region are to be used, and sets out policies for achieving sustainable management of these resources. The Regional Policy Statement sets out strategies for regional development, transportation and energy consumption. These strategies are intended to ensure that development and change in the region is managed in a manner which protects natural values and improves urban efficiency, without undermining opportunities for social and economic activity.

The ARPS proposes policies and methods to address the significant issues by preparing a Regional Plan and through the Regional Land Transport Strategy (RLTS). Comprehensive policy options regarding the preparation of the transport network required to support the preferred form of urban development are included in the RLTS, the Regional Plan and Auckland Strategic Planning Model (ASPM).

The objectives for transportation planning were to:

i) plan and promote development of a transport system which supports the preferred form of urban development;
ii) guide development of the transport system in a way which reduces the adverse effects of transport on the environment;
iii) guide development of the transport system so as to enable the efficient movement of people, goods and services and resources in a way which is cost effective, affordable and safe.

The major directions of urban growth and transport issues and policy options in Auckland are set out in the Regional Policy Statement. The following issues underlie the policy preferences:

i) the continuing expansion of the urban areas onto land which is valued for its agricultural, ecological and aesthetic qualities;
ii) the emission into the air of a variety of pollutants, including greenhouse gases;
iii) the lowering of water quality in waterways and harbours by polluted runoff from roads, including lead, zinc and petrochemicals;

iv) relatively high use of energy and reliance on consumption of non-renewable resources both in fuel use and land use.

These give rise to a number of principles for transportation planning:

i) development of a transport system which supports the preferred form of urban development;
ii) minimising environmental degradation;
iii) meeting accessibility needs for all groups in the community;

The Regional Policy Statement emphasised a preferred form of urban development, but did not provide operational criteria to achieve this objective. The form of development most consistent with sustainability is not clear in the Policy Statement. However, the Policy Statement does give broad guidelines for developing the transportation system to reduce adverse effects on the environment, including air and water quality. A desirable transport system will reduce the need to use renewable fuel and mitigate the adverse effects on local amenities. Appropriate transport links between major activity centers and the effectiveness of the public transport system are vital to guide development of a transport system which is as cost effective, affordable and as safe as practicable.

Alternative options for efficient public transport are also covered as they propose to manage those without access to a car to get to work, services, shops, social and recreational facilities. The efficiency of public transport in congested transport corridors will be increased by encouraging an increase in person-carrying capacity (car pooling and high vehicle occupancy).

The following objectives are included in the Regional Policy Statement for energy use in Auckland:

i) to promote the efficient and sustainable use of energy resources;
ii) to avoid or mitigate the adverse affects of proposals relating to the generation, distribution and use of energy.

The following issues are identified in the Regional Policy Statement for energy use in Auckland:

i) More efficient use needs to be made of energy;

ii) There is currently high dependence on non-renewable fuels;

iii) The existing form of urban development in Auckland, including the associated transportation system, is not sustainable in terms of current energy use.

iv) The generation, distribution and use of energy is essential for the development, well being and prosperity of the Auckland region, but have major adverse environmental effects;

v) There is a conflict among "players" concerned with the management of energy resources.

The proposed Regional Policy Statement promotes reduction in the wasteful use of energy and the application of energy efficiency. The policy states the importance of energy conservation in the manufacturing and construction industries and describes the building design, site layout and design/operation of transport vehicles.

The ARPS proposes policies to ensure that development and changes in population, employment and dwellings in the region are managed in a manner which protects the natural values of the region, improves urban efficiency and provides opportunities for social and economic activities (Table 7.7). The issues identified in ARPS are framed with reference to the Resource Management Act, such as: minimising the adverse effects of transport on the environment; enabling the accessibility needs of all groups in the community to be met; enabling the efficient movement of people, goods, services and resources, and developing the transport system in a way which maximises road safety.

The Regional Policy Statement addresses some options for dealing with continued growth as one of the significant resource management issues facing Auckland and recognises that an appropriate transportation system is a vital component of any regional development strategy. It is one of the options in the ARPS that growth should be contained along the major corridors and within selected areas. The areas for intensification are identified in the Regional Policy Statement. The ARPS also identifies future land transport needs of the region and the most desirable means of responding to those needs in a way which is safe, cost effective and takes into account environmental effects and an appropriate role for each mode of transport.

The Regional Policy Statement and the criteria both recommend policy which emphasises that transportation infrastructure is a major determinant of the form of urban development, as it affects the

environment and the efficiency with which the region operates. It is important to know whether the preferred form of urban development and the infrastructure necessary to support it is a sustainable form of development or haphazard, unplanned, inefficient and expensive development. The policies of sustainability are in line with development policy options included in the ARPS. The land use, urban form, density control and transport options are vital to determine the preferred form of urban development for Auckland, which can be improved by selecting sustainable principles

In ARPS the maximum emphasis is given to policies related to land use, future infrastructure development and urban form and development of viable transport network. The sustainability criteria emphasis those factors, along with factors associated with behavioural change, energy efficiency and regulating vehicle use. It is evident that the majority of policy recommendations contained in the proposed criteria are similar to those identified in the Regional Policy Statement.

The analysis of plans and policies in the Proposed Auckland Regional Policy Statement against the criteria for sustainability suggests 43 consistent and 89 irrelevant policy options (Table 7.8). The polices which are consistent include selective intensification, fewer trips, efficient mode of public transport, reduction of the need for private transport and reduction for travelling in congested areas by increasing passenger carrying capacity. However, there are number of irrelevant policies regarding identification of major activity centers in the regional and district plans and the development of transport network and road safety principles.

The first, second, fifth and sixth policy options are almost fully consistent with a sustainability criteria. All provisions made under policy options one five and six offer high potential for sustainability. The Proposed Auckland Regional Policy Statement fostered land use plans which are less car oriented and oriented to urban containment and selective intensification. No policies go against the spirit of sustainability. The plan provided necessary infrastructure based on predicted need and according to a vision of inward development or development at the boundaries of the city. The plan supported the development of public transport and increasing the passenger carrying capacity of public transport.

Overall, the policies in the Proposed Auckland Regional Policy Statement 1994 are consistent with the sustainability criteria. Only two policies in the plan have less consistent policies, those dealing with identification of growth poles at regional and district levels. There are no inconsistent policy options in the plan.

Table 7.7
THE PROPOSED AUCKLAND REGIONAL POLICY STATEMENT 1994

ISSUES	OBJECTIVES	POLICY RECOMMENDATIONS
1) Developing a transport system which supports the form of urban development.	1) To plan and promote development of a transport system which supports the preferred form of urban development.	1) The transport network which is required to support the prefered form of urban development will be planned and implemented.
2) Minimising adverse effects of transport on the environment.	2) To guide development of the transport system in a way which reduces adverse effects of transport on the environment.	1) Development of the transport system will be guided in a way which: i) reduces its adverse effects on the environment, including air quality and water quality; ii) reduces the need to use non-renewable fuels; iii) mitigates the adverse effects on local amenities.
3) Enabling accessibility needs of all groups in the community to be met.	3) To guide development of the transport system so as to enable the efficient movement of people, goods, services and resources in way which is cost effective, affordable and as safe as practicable.	1) Appropriate transport links between major activity centers will be identified in the Regional Plan and required to be protected in District Plans. 2) The effectiveness of the public transport system will be improved to ensure that it meets the needs of existing and potential

4) Enabling the efficient movement of people, goods, services and resources. 5) Developing the transport system in a way which maximises road safety.		users. This will be done by reviewing services and upgrading facilities. 3) The public transport system will be managed to better enable those without access to a car to get to work, services, shops and social and recreational facilities. 4) The efficiency of congested transport corridors will be increased by encouraging increases in person-carrying capacity (ie. by supporting public transport, car pooling and high occupancy vehicles) rateher than vehicle capacity. 5) Priority areas will be identified for the targeting of road safety resources and increase cooperation and information sharing between road safety groups. 6) Central government will be requested to ensure that funding is available to enable the development of a safe, effective, affordable transport system.

TABLE 7.8 MAIN POLICY OPTIONS UNDER THE PROPOSED AUCKLAND REGIONAL POLCIY STATEMENT 1994 VS SUSTAINABILITY CRITERIA

SUSTAINABILITY CRITERIA	T. network to support the prefered form of urban develop-ment	Develop-ment of T. network to reduce: e. effects, need for f.fuel and mitigate adverse effects on local amenities & road safety.	Identificat-ion of major activity centers in the Regional & District Plans	Improve-ments in public transport to meet the needs existing & potential users.	Public transp-ort for carless to get to job, services, shops, & social & other activities	Increase in passengers. carrying capacity & p.transport car pooling & ride sharing etc.
use, Urban Form and ity Control						
e intensive land uses by creating a compact city.	C	na	C	na	na	na
ı densities along and within the major corridors wing mixed use and dual occupancy housing.	C	na	na	C	C	C
tiple family development in transit corridors.	na	na	na	C	C	C
e centralised land use to encourage walking cycling	na	na	na	na	C	C
trolling new development in urban as by balancing jobs and population required upport it.	na	na	na	na	C	C
grated new development for energy conservation efficiency.	na	na	na	na	na	na
onment, Energy and sport Viability						
rnative modes of transport such as ride ring and park and ride.	na	na	na	na	C	C
and efficient public transport systems. ycle routes.	C	C	na	na	C	C
estrians connection in the city center and sub-ters.	na	na	na	na	na	C
s transit programs in high density corridors.	na	na	na	na	C	C
h occupancy transport modes.	na	na	na	na	C	C
ıting future developable land and land transport ds.	C	C	C	C	C	C
ısuring energy use and emission.	na	C	na	na	na	C
easing overheads for private cars within Central siness District.	na	na	na	na	na	na
ıncing transport, socio-economic, and vironmental needs through regulatory measures.	na	C	na	c	na	na
vioural Changes And latory Measures						
ourage development in the CBD to achieve urban ıtainment.	C	na	C	na	na	na
ıversion of existing parking lots and under utilised d located in the Central Business to more intensive ted land uses.	C	na	C	na	C	na
ulating vehicle numbers.	na	na	na	na	na	na
es on vehicle use.	na	C	na	na	na	na
n Design						
ieve density between 20 and 40 persons per tare by designing mixed use development.	C	na	na	na	na	na
h rise construction in the CBD in urban areas nnected by pedestrian tubes on various levels.	C	na	na	na	na	na
d orientation and layout pattern for energy ıservation.	C	na	na	na	na	na
SUMMARY TOTAL						
ISTENT (C) 43	**9**	**5**	**4**	**4**	**10**	**11**
NSISTENT (ic) 0	**0**	**0**	**0**	**0**	**0**	**0**
APPLICABLE (na) 89	**13**	**17**	**18**	**18**	**12**	**11**
ON C:IC 43:0	**9:0**	**5:0**	**4:0**	**4:0**	**10:0**	**11:0**

7.8 AUCKLAND REGIONAL LAND TRANSPORT STRATEGY 1994

The Auckland Regional Land Transport Strategy (ARLTS) is required to be prepared by the Regional Council under the provisions of the Transit New Zealand Act 1989 as amended in June 1992. The overall objective of the strategy is to provide a framework for the development and management of a safe, efficient and effective transport system which contributes to sustainable management of natural and physical resources of the Auckland region and to the well being of the community.

Alternative options and policy recommendations in the Land Transport Strategy (1994) are developed, keeping in view the objectives set out in the Regional Policy Statement. To achieve the objective regarding the region's natural and physical resources, the policy option which supports containment and selective intensification has been adopted in the Auckland Regional Land Transport Strategy. Other policy options are included in the Auckland Regional Land Transport Strategy to achieve the following land transport objectives:

i) reduction in the adverse effects of transport on the natural and physical environment;
ii) meeting accessibility needs of all groups in the community;
iii) efficiency in the movement of people, goods, services and resources and improved road safety;

Five specific objectives are set out in the Auckland Regional Land Transport Strategy and various policy options are developed to achieve each objective. Those five objectives are shown in Table 7.9.

Private cars are the dominant transport mode in the Auckland Region as they provide a high level of personal mobility for lifestyle and improved level of economic activity. The long-term aim of the strategy is to encourage a form of urban development which requires less vehicle travel and more trips to be made jointly in fewer vehicles, or without vehicles.

Public Transport plays three important roles in the strategy. The first role is provision of mobility for those without access to a car, including the young, elderly, poor and people with disabilities. In a low density city like Auckland, public transport provides mobility essential to give these groups access to work, recreation, social activities, health facilities and other necessities.

Two other roles that public transport perform are; reducing the environmental impacts of motor vehicles by providing a more environmently friendly alternative, and private car travel reducing traffic congestion, particularly on main roads during peak periods. Public transport does have environmental impacts, but it is important to note that environmental impacts per passenger-trip for public transport are less than by car. Similarly, on some corridors roads are already at capacity, with no realistic opportunities to increase their vehicle-carrying capacity. The only option is to increase the person-carrying capacity of the corridor. The keys to achieving these objectives are to increase public transport percentage and to use public transport which has a greater passenger carrying capacity, perhaps throughout on its own right-of-way, either rail, busway, or bus priority lane. Increased ride sharing will also reduce congestion and environmental impacts of the transport system.

Studies on population, employment, number of cars and dwellings units, vehicle trips/person and trip making in Auckland show that past development trends have changed the region dramatically over the last twenty years. North Shore development and the decentralisation of various activities has a lot to do with cross-commuting. The decline of employment in the Central City is another factor contributing to increasing vehicle trips/person and trip making in Auckland. Since the region has limited ability through traditional development patterns to accommodate further growth within existing boundaries, other options such as consolidation, mixed-use development, urban concentration and intensification of residential and other activities within transport corridors and intensification of various activities at certain nodal points have to be examined to deal with problems of high urban growth.

Policy options in the Auckland Regional Land Transport Strategy 1994 regarding urban form, land use and density control are similar to the sustainable criteria. The land outcome of this process is likely to be that expansion into new areas is constrained and growth is limited to where infrastructure facilities, including transport, can be provided efficiently.

The analysis of plans and policies in the ALTS against criteria for sustainability suggests 60 consistent and 72 irrelevant policy options. This plan has more consistent policies than all the previous plans. Polices which are consistent include selective intensification, fewer trips, efficient mode of public transport, reduction of need for private transport and reduction for travelling in congested areas by increasing passenger carrying capacity. However, there are a number of irrelevant policies regarding introduction of heavy vehicle routes and prioritising network improvements.

The first, second and sixth policy options in the ARLTS are almost fully consistent with the sustainability criteria. There are a few irrelevant policies regarding energy efficiency and urban design criteria. More than 64% of policy options under policies one, two and six offer the potential for sustainability.

The ARLTS support for land use planning that is less car oriented and encourages selective intensification, efficient public transport and alternative modes of transport. Criteria for reducing the need for private transport, not only improve environmental quality but also, control fuel use. The ARLTS recommended as a preferred form of development one which reduces growth for travel in congested corridors. It encourage increased passenger carrying capacity in high density residential areas and major corridors. A sustainable planning approach has been adopted to meet the transport needs of the growing city by providing reasonable accessibility for all community groups. The plan provides for the necessary infrastructure based on predicted need according to a vision of continued growth within the metropolitan area.

Policy options encouraging use of efficient modes of transport and discouraging use of inefficient modes are included. The proposed methods of encouraging use of public transport include developing services which meet the needs of existing and potential users in terms of ease of use, affordability, comfort and security, and developing schemes which improve the travel time of public transport relative to cars. Ride sharing and car pooling are proposed method in the strategy for increasing average car occupancy. Walking and cycling are alternative modes of transport which can be effective by considering the needs of walkers and cyclists when designing for their needs. All these policy options require a major shift in behaviour through promotion in the media, regulatory measures, and intervention of local councils.

Table 7.9

THE AUCKLAND REGIONAL LAND TRANSPORT STRATEGY 1993

GOAL	OBJECTIVES	POLOCY RECOMMENDATIONS
To provide a framework for the development and management of safe, efficient and effective transport system which contributes to the sustainable management of the natural and physical resources of the Auckland region and the well being of the community.	1 To contribute to the sustainable management of the region's natural and physical resources.	a) Introduce transport and land use measures supporting containment and selective intensification measures. b) Encourage the use of efficient modes of transport. c) Discourage the use of inefficient modes of transport. d) Support measures which will result in fewer or shorter vehicle trips.
	2) To reduce the adverse effects of transport on the natural and physical environment.	a) Reduce the need for motor vehicle travel and encourage fuel efficiency, thus reducing the amount of emissions; b) Limit adverse effects on the quality of receiving waters through treating discharges from roads where this can be done in a cost effective manner. c) Limit adverse effects on air quality through voluntary and educational programmes directed at reducing emissions "at the tailpipe". d) Introduce traffic calming measures where appropriate. e) Introduce noise reduction measures where appropriate, and f) Introduce Heavy Motor Vehicle routes where appropriate.
	3) To meets accessibility needs of all groups in the community.	a) Ensure that the public transport system provides a reasonable level of accessibility for all

		groups(including those without access to a motor vehicle). b) Provide for people with special transport needs. c) Increase and enhance the opportunities for walking & cycling. d) Enhance the accessibility of major institutions. e) Investigate the need for new T.links to improve accessibility between main activity areas.
	4) To enable the efficient movement of people, goods, services and resources.	a) Establish and protect the current/ future transport network. b) Protecting the ability to construct Light Rail Transit in the Southern and Western Rail Corridor. c) Improve the effectiveness of public transport. d) Develop criteria for evaluating and prioritising proposed network improvement. e) Reduce growth in demand for vehicle travel in congested areas and corridors. f) Investigate the use of economic instruments to decrease the demand for vehicle travel in congested and corridors. g) Increase the person carrying capacity of the transport system in congested corridors and areas by supporting high occupancy transport modes.
	5) To improve road safety.	a) Improve cooperation between groups working in the field of road safety. b) Ensure road safety resources are effectively targeted. c) Reduce traffic growth. d) Ensure that increases in the uses of "slow modes" are achieved safely. e) Improve traffic engineering measures to make roads safer for all road users. f) Increase the use of Safety Audit Procedures

TABLE 7.10 MAIN POLICY OPTIONS UNDER THE AUCKLAND LAND TRANSPORT STRATEGY 1994 VS SUSTAINABILITY CRITERIA

SUSTAINABILITY CRITERIA	Seletive intensif-ication, fewer trips, efficient mode of transp-ort discou-rage ineffici-ent T Mode	Reduce the need for p.transport (fuel efficiency, reduction in emmisions), limit adverse effects on quality of run-off water	Traffic calming , noise reduct-ion and introdu ction of heavy vehicle routes	Reasonable level of accessibil-ity for all groups, p.transport new rail links & encourag-ing alternative mode of transport	Establish & protect the current / future t..network through criteria for priortising network improve-ments	Reduce growth for travel in congest-ed areas, increas-ing person carrying capacity in con-gested corridors
and use, Urban Form and Density Control						
More intensive land uses by creating a compact city.	C	C	C	C	na	C
High densities along and within the major corridors allowing mixed use and dual occupancy housing.	C	C	na	C	na	C
Multiple family development into transit corridors.	C	C	na	C	na	C
More centralised land use to encourage walking and cycling	C	C	na	na	na	C
Controlling new development in urban areas by balancing jobs and population required to support it.	C	C	na	C	C	C
Integrated new development for energy conservation and efficiency.	na	na	C	C	C	C
nvironment, Energy and ransport Viability						
Alternative modes of transport such as ride sharing and park and ride.	na	C	na	C	na	C
Safe and efficient public transport systems, bicycle routes.	C	C	na	C	na	C
Pedestrians connection in the city center and sub-centers.	C	C	na	C	na	C
Mass transit programs in high density corridors.	na	C	na	C	na	C
High occupancy transport modes.	C	C	na	C	na	C
Relating future developable land and land transport needs.	C	C	na	C	C	C
Measuring energy use and emission.	C	na	C	na	na	na
Increasing overheads for private cars within Central Business District.	na	C	na	na	na	na
Balancing transport, socio-economic, and environmental needs through regulatory measures.	C	na	C	na	na	na
ehavioural Changes And egulatory Measures						
Encourage development in the CBD to achieve urban containment.	C	C	na	na	na	C
Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	C	C	na	na	na	C
Regulating vehicle numbers.	na	na	na	na	na	na
Rules on vehicle use.	na	na	C	na	na	na
rban Design						
Achieve density between 20 and 40 persons per hectare by designing mixed use development.	na	na	na	na	na	na
High rise construction in the CBD in urban areas connected by pedestrian tubes on various levels.	na	na	na	na	na	na
Good orientation and layout pattern for energy conservation.	na	na	na	na	na	na
SUMMARY TOTAL						
ONSISTENT (C) 60	13	14	5	11	3	14
NCONSISTENT (ic) 0	0	0	0	0	0	0
OT APPLICABLE (na) 72	9	8	17	11	19	8
ATIO C:IC 60:0	13:0	14:0	5:0	11:0	3:0	14:0

7.9 THE AUCKLAND STRATEGIC PLANNING MODEL 1994

The Auckland Regional Council has developed the Auckland Strategic Planning Model (ASP) which is the strategic policy and planning component of the Auckland Transport Model (ATM). The ATM Project arose from a Transit NZ requirement to revise the ARC Transport Model, that is, the Comprehensive Transport Study (CTS).

The ASP is an inter-active land use/transport model which can model a range of development scenarios in order to assess the regional resource management policy consequences. It is a general model for evaluating alternative development options across a number of criteria and uses them for input to the ATM.

The ASP Model Project includes the provisions of information for the following functions:

a) **Transport Planning**

- input to the Auckland Regional Transport Model which will be the basis of the Regional Land Transport Strategy (RLTS) required under the Transit NZ Act and any future Regional Transport Plan which may be required to support the Auckland Regional Policy Statement (ARPS);

b) **Strategic and Environmental Management Policy**

- information to the ongoing Section 32 (RMA) analysis which will support the strategic direction and development policies in the ARPS;
- inputs to resource quality Regional Plans and consent process;
- information for ongoing S35 (RMA) monitoring of the resource base and regional policy;
- inputs to other regional land authority resource management process such as the Watercare Services Ltd Wastewater 2000 project.

The objective of the ASP Model evaluation process is to give an indication of trade-offs which may need to be made when formulating public resource management policies and allocating sector finance for capital works and systems maintenance.

There are four separate but inter-related evaluation sub-models:

1. environmental (likely consequences for the resource base);
2. economic (development capacities and costs);
3. social (community well being factors); and
4. strategic (likely acceptability of any policy direction and implications for the present regional development direction).

The purpose of the environmental consequences sub-model is to determine the relative impact of the policy options on the existing state of the regional environment. The environmental consequences sub-model deals with the:

- impact on land of urbanisation; and
- impact of transport system on fuel use and emission factors.

Four development options were evaluated in the Auckland Strategic Planning Model in the first round of the modelling exercise which dealt with different policy options which are different forms of urban containment and intensification. The alternative development options and policy recommendations were developed with regard to the objectives set out in the Auckland Regional Land Transport Strategy and the Auckland Regional Policy Statement. These policy options also support containment and selective intensification as has been identified in Auckland Regional Policy Statement 1994. The four policy options focussed on the following land transport objectives:

Option 1: Continued development in all sectors where all Future Urban Development Zones (FUDZs) within the metropolitan limits are utilised by 2021.

Option 2: Northern development emphasis which develops the northern FUDZs, but defers development of the southern FUDZs.

Option 3: Southern emphasis which develops the southern FUDZs but defers development of the Northern FUDZ.

Option 4: Existing Urban Area emphasis where development intensification at selected nodes in a manner compatible with relevant policy direction.

Overall goal, objectives and policy options associated with the future development scenarios under this model are given in Table 7.11. ASP is a model in itself which reveals nothing about sustainability. Options can be tested with it. Some may be sustainable others may not.

The ranking of the evaluation factors are shown in Table 7.12 for comparison across all four policy options included in ASP. Each factor is ranked from highest to lowest adverse impact (1 to 4) within the following themes:

- Resource base consequences;
- Development capacity (opportunity) and costs;
- Community well-being; and
- Acceptability of policy direction.

Option 1 in the ASP emphasised continued development within the current metropolitan limits in all four urban zones ie (central, northern, southern and western) in Auckland. This policy option suggests least overall changes from present development patterns. It would have the greatest impact on use of the resource base. It would have the second lowest impact on public capital costs and development opportunities after those of option 3. It would have the least adverse impacts on community well being and likely be the most acceptable option because of its least degree of public intervention and risk. The least public intervention and least changes in present development pattern approaches would bear the costs of the high impact on use of the resource base (land).

The option 2 would bring about a high degree of change in regional development patterns and have the highest public capital and private sector costs. Additionally, it would impose the greatest constraints to development opportunity and servicing capacities as well as having the highest adverse impact on

community well being. However, it would have the second lowest impact on use of the resource base. It would have high public sector capital costs and the degree of public intervention and risk and second scored community acceptability.

Table 7.11
THE AUCKLAND STRATEGIC PLANNING MODEL 1994

GOAL	OBJECTIVES	POLICY OPTIONS
To assess the regional resource management policy consequences.	i) To develop technology, skills and information base to enable ongoing consequences of any form and direction of regional urban development to be assessed; ii) To provide information for: a) Transport Planning by giving input to ART Model which will provide the basis of the Regional Land Transport Strategy (RLTS) required under the Transit NZ Act, and any future Regional Transport Plan which may be required to support the PRPS; b) Strategic and Environmental Management Policy • input to any Regional Development Plan required to support the PRPS; • information to ongoing Section 32 (RMA) analysis which will support strategic direction and development policies in the PRPS; • input to resource quality Regional Plans and consent process; • information for ongoing S35 (RMA) monitoring of the resource base and regional policy; • input to other regional land authority resource management process such as Watercare Services Ltd Wastewater 2000 project.	1. Continued development in all sectors where all Future Urban Development Zones (FUDZs) within the metropolitan limits are utilised by 2021. Levels of residential intensification over much of the urban area (especially isthmus) is increased. 2. Northern development emphasis which focuses development on the Northern urban areas, brings in the northern FUDZs and allows limited development of the Okura block. Otherwise the Northern metropolitan limits are held. The southern metropolitan limits also remain, but development of the Southern FUDZs are deferred. The option increases residential intensification in both the Northern and Central Urban areas. Employment growth in the Northern Urban Area is emphasised. 3. Southern development emphasis which focuses development in the Southern Urban Area within the metropolitan limits, and increases residential intensification in the Southern and Central Urban Areas. The Northern FUDZs is deferred and Southern and Central Urban area employment centers dominate. 4. Existing urban area emphasis where development focuses on the existing urban areas with intensification at selected nodes and non-development of all current Future Urban Development Areas. In effect this would bring current metropolitan limits inward.

TABLE 7.12 SUMMARY OF EVALUATION FACTORS RANKING

FACTORS	POLICY OPTION AND RANKING			
	1	2	3	4
1. Resource Base Consequences:				
• extent of new greenfields urbanisation	1	3	2	4
• marine sediment quality	4	3	2	1
• stormwater quality	3	2	1	4
• stormwater/flood control	1	4	2=	2=
• air quality	n/a	n/a	n/a	n/a
• landscape quality	1	2	3	4
• environmental impact of the transport system	2	1	3	4
2. Development Capacity(opportunity) and costs:				
• water supply	3	1	4	2
• drainage	4	3	2	1
• energy/consumption	2	1	3	4
• transportation (with mass transit)	2	1	3	4
(no mass transit)	2	1	4	3
• development	4	1	3	2
• open space provision	3	1	4	2
• social services provision (education)	1	4	3	2
1. Community Well Being:				
• changes in living location opportunity	2	1	3	4
• changes in employment location opportunity	no	appreciable	difference	
• disruption from change	3=	2	3=	1
• change to community facilities	4	2	3	1
2. Acceptability of Policy Direction:				
• acceptable degrees of changes	4	2	3	1
• acceptable public capital costs (mass transit option)	3	1	4	2
• public intervention required	3=	2	3=	1
• acceptable degree of risk	4	2	3	1

Source: Auckland Strategic Planning Model, 1994.

Option 3 would bring about little change to regional development patterns and has greatest impact on use of resource base. It would have second least impact on community well being factors and the least adverse impact on public capital costs and capacity thresholds. This policy option stands as the second most acceptable, because of the low degree of public intervention and risk involved.

Policy option 4 would result in the most change to regional development patterns, but have the least impact on the resource base. It would impose the second highest constraints to development and servicing, as well as the second highest adverse impact on community well being. In addition, it would have the second highest public capital costs, allowing for construction of a mass transit system. Overall, it would have the least acceptable degrees of change and risk, and a high level of public intervention. This option is ranked as the least acceptable policy option.

Table 7.13 shows that there are 68% consistent and 32% irrelevant criteria in Policy Options 1 of ASP when compared to the sustainablity criteria. This option shows maximum compatibility with sustainability criteria of all four options. The sustainability criteria covering land use, urban form and urban design are given a high priority in Option 1. More than 90% of criteria under environment and transport viability and 100% criteria regarding land use and urban design are consistent in Option 1, which also has more consistent policies than ARPS and ALTS.

The policy option 2 has 55% policies consistent and 45% irrelevant policies when compared with the sustainablity criteria, and scores worse on these ground than options 1 and 3. The sustainability criteria regarding land use, urban form, environment and transport viability are given a high priority in option 2. More than 90% criteria under land use and 50% in environment and transport viability are consistent in option 2 of ASP.

The third policy option has 50% consistent and 50% irrelevant criteria compared to the sustainablity criteria. This option contains the least consistency among all four policy option included in ASP. The sustainability criteria regarding land use, urban form and behavioural change are given high priority in option 3.

Policy option 4 has 59% consistent and 41% irrelevant policies when compared to the sustainablity criteria. This option contains second highest consistent policies among all four options under ASP. The sustainability criteria are matched in respect of the environment, transport viability and urban

design policies in option 4. More than 85% criteria under environment, transport viability and urban design are consistent in option 4 of ASP. This option has more consistent policies than ARPS and ALTS, but less than option 1.

All policy options have some consistency with the criteria for sustainability. Option 1 has the highest number of factors that interrelate and overlap with the sustainability criteria. This option shares the lowest impact ranking, although it would be costly on use of land resource. Although Option 4 has second highest number of policies meeting sustainability criteria, it has a high risk and requires a high level of public intervention.

TABLE 7.13 MAIN POLICY OPTIONS UNDER THE AUCKLAND STRATEGIC PLANNING MODEL 1994 VS SUSTAINABILITY CRITERIA

SUSTAINABILITY CRITERIA	Continued developm-ent in all sectors upto year 2021. Supported levels of residential intensifica-tion in the central urban area OPTION 1	Focus on northern development &southern development are deferred. This option increases residential intensification in both the Northern & Central UA. Employement growth is emphasis OPTION 2	South dev-elopment emphasis, increases intensificat-ion in central and southern and nothern developm-ent is deffered. OPTION 3	Existing urban area emphasis with intensifica-tion at selected nodes and inward developm-ent is encouraged OPTION 4
and use, Urban Form and ensity Control				
More intensive land uses by creating a compact city.	C	C	na	na
High densities along and within the major corridors allowing mixed use and dual occupancy housing.	C	C	C	na
Multiple family development in transit corridors.	C	C	C	na
More centralised land use to encourage more walking and cycling	C	C	na	na
Controlling new development in urban areas by balancing jobs and population required to support it.	C	C	C	C
Integrated new development for energy conservation and efficiency.	C	C	C	na
vironment, Energy and ansport Viability				
Alternative modes of transport such as ride sharing and park and ride.	na	na	na	na
Safe and efficient public transport systems, bicycle routes.	C	C	na	C
Pedestrian connection in the city center and sub-centers.	C	na	na	C
Mass transit programs in high density corridors.	na	C	C	C
High occupancy transport modes.	na	C	na	C
Relating future developable land and land transport needs.	C	C	na	C
Measuring energy use and emission.	na	na	na	C
Increasing overheads for private cars within Central Business District.	C	na	na	na
Balancing transport, socio-economic, and environmental needs through regulatory measures.	na	na	na	na
havioural Changes And gulatory Measures				
Encourage development in the CBD to achieve urban containment.	C	C	C	C
Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	C	C	C	C
Regulating vehicle numbers.	na	na	na	na
Rules on vehicle use.	na	na	C	C
ban Design				
Achieve density between 20 and 40 persons per hectare by designing mixed use development.	C	na	C	C
High rise construction in the CBD in urban areas connected by pedestrian tubes on various levels.	C	na	C	C
Good orientation for energy conservation.	C	na	C	na
CONSISTENT (C)	**15**	**12**	**11**	**13**
	0	**0**	**0**	**0**
NOT APPLICABLE (na)	**7**	**10**	**11**	**9**
	15:0	**12:0**	**11:0**	**13:0**

7.10 SUMMARY

Five different plans and the preferred policy option for Auckland included in the ASP model have been assessed against the criteria of sustainability derived in Chapter 4. Two of these plans and ASP has been prepared under the Resource Management Act 1991. The earlier plans encourage as non-sustainable. There is a slight shift towards sustainability in the Comprehensive Transport Study 1973-75. The last two plans together with the ASP reflect a strong shift toward sustainability.

Table 7.14 summaries these analysis. All plans have been evaluated against the following key elements of sustainability:

1. land use and urban form;
2. transport viability;
3. behavioural change; and
4. design of built environment.

The Master Transportation Plan 1954-55 contains one consistent policy against 6 inconsistent and 15 not applicable policies. The only consistent policy falls under the key element of transport viability, which encouraged the development of a public transport system. All inconsistent policies appeared under the key element of sustainable criteria regarding land use and urban form. Policies under behavioural changes and design of built environment are irrelevant in case of the Master Transportation Plan. In this plan, the ratio of consistent to inconsistent policies is 1:.17. Only 5 % of the 22 sustainability criteria are met within the plan.

Once again, more inconsistent (seven) than consistent (three) policies appeared in the Comprehensive Transportation Study 1963-65. There are only three consistent policies in the plan; this appeared under the key element of transport viability. The elements under behavioural change and design of built environment are irrelevant. The ratio of consistent to inconsistent polices is 1:.43 which means the plan was more sustainable in term of the criteria. Nevertheless, only 14% of the 22 sustainability criteria were met.

TABLE 7.14 MAIN POLICY OPTIONS UNDER VARIOUS PLANS VS SUSTAINABILITY CRITERIA

SUSTAINABILITY CRITERIA	THE MASTER TRANSPORTATION PLAN 1954-55	THE COMPREHENSIVE TRANSPORTATION STUDY 1963-65	AUCKLAND COMPREHENSIVE TRANSPORTATION STUDY 1973-75	PROPOSED AUCKLAND REGIONAL POLICY STATEMENT 1994	AUCKLAND LAND TRANSPORT STRATEGY 1994	AUCKLAND STRATEGIC PLANNING MODEL 1994 PREFERED OPTION
Land use, Urban Form and Density Control						
1. More intensive land uses by creating a compact city.	ic	ic	ic	na	na	C
2. High densities along and within the major corridors allowing mixed use and dual occupancy housing.	ic	ic	C	C	C	C
3. Multiple family development in transit corridors.	ic	ic	C	C	C	C
4. More centralised land use to encourage more walking and cycling	ic	ic	ic	C	C	C
5. Controlling new development in urban areas by balancing jobs and population required to support it.	ic	ic	ic	na	C	C
6. Integrated new development for energy conservation and efficiency.	ic	ic	ic	na	C	C
Environment, Energy and Transport Viability						
1. Alternative modes of transport such as ride sharing and park and ride.	na	C	na	C	C	na
2. Safe and efficient public transport systems, bicycle routes.	C	na	C	C	C	C
3. Pedestrian connection in the city center and sub-centers.	na	na	na	C	C	C
4. Mass transit programs in high density corridors.	na	C	C	C	C	C
5. High occupancy transport modes.	na	C	C	C	C	na
6. Relating future developable land and land transport needs.	na	na	na	na	na	na
7. Measuring energy use and emission.	na	na	na	na	na	C
8. Increasing overheads for private cars within Central Business District.	na	na	C	na	na	na
9. Balancing transport, socio-economic, and environmental needs through regulatory measures.	na	na	na	C	C	C
Behavioural Changes And Regulatory Measures						
1. Encourage development in the CBD to achieve urban containment.	na	ic	ic	na	na	C
2. Conversion of existing parking lots and under utilised land located in the Central Business to more intensive mixed land uses.	na	na	ic	C	C	C
3. Regulating vehicle numbers.	na	na	na	na	na	na
4. Rules on vehicle use.	na	na	na	C	na	na
Urban Design						
1. Achieve density between 20 and 40 persons per hectare by designing mixed use development.	na	na	ic	C	na	C
2. High rise construction the CBD in urban areas connected by pedestrian tubes on various levels.	na	na	ic	na	na	na
3. Good orientation and layout pattern for energy conservation.	na	na	na	C	na	C
CONSISTENT (C)	**1**	**3**	**6**	**13**	**12**	**15**
INCONSISTENT (ic)	**6**	**7**	**8**	**0**	**0**	**0**
NOT APPLICABLE (na)	**15**	**12**	**7**	**9**	**10**	**4**
RATIOS	**!:.17**	**.43**	**1:.67**	**13:0**	**12:0**	**15:0**
% CRITERIA SHARED	**5**	**14**	**27**	**59**	**54**	**68**

The Auckland Comprehensive Transportation Study 1973-75 contains six consistent policies under the key elements of land use, urban form and transport viability. Inconsistent policies appeared under key elements of behavioural changes and design of built environment. The ratio of consistent to inconsistent policies is 1:.67 in Auckland Comprehensive Transportation Study 1973-75 which is higher than the Master Transport Plan and Comprehensive Transport Study 1963-65. Some 27% of sustainability criteria are met in this plan.

By contrast, 59% of the policies in the Proposed Auckland Regional Policy Statement are consistent with sustainability, suggesting a significant shift in the direction of sustainability. These appeared under fourth key element that cover land use, urban form, transport viability and designs of built environment. There are no inconsistent policy in the ARPS.

The Auckland Land Transport Strategy has 56% consistent policies. These appeared under the key elements land use, urban form, transport viability and behavioural changes. Once again, there are no inconsistent policy in the ALTS like the ARPS.

Option 1 in the Auckland Strategy Planning Model has 68% consistent policies and 32% irrelevant criteria. This option shows maximum consistency compared to other three options included in ASP. The sustainable criteria regarding land use, urban form and urban design are pre-dominant in Option 1. More than 90% criteria under environment and transport viability and 100% criteria regarding land use and urban design are consistent in option 1 of ASP. This option has the highest consistent policies than ARPS and ALTS.

The consistent policies appeared under all key elements ie. land use, urban form, transport viability, behavioural changes and design of built environment. There is once again no inconsistent policy in ASP Model like the ARPS and the ALTS.

The Policy options under various plans have some consistent, inconsistent or irrelevant policies. However, the most recent plans have shown a major shift from a development approach to an approach which is consistent with or even promotes urban sustainability.

7.11 CONCLUSIONS

Policy options favouring increased density will be slow in taking effect. The effect of planning for urban sustainability will be limited to changes which can be made "at the margin". Auckland has always been characterised by low density housing which has arisen partly as a result for the availability of low cost land. A restrictive planning approach aimed at changing urban form through containment is necessarily long term in nature and effect, but one of several possible policy options. The social, commercial and political obstacles to increasing residential densities are also faced with resistance because of entrenched attitudes.

The benefit of low density living is nevertheless high and environmentally attractive. Certain social benefits arise from high density urban form, such as the potential for a more vibrant urban life, support for social, educational and recreational activities, and ready access to them. Those people who do not have access to cars or have a disability can also enjoy city life by way of walking and using public transport.

The decline in Auckland's traditional urban centre since 1950's due to the development of suburban commercial activities serviced by private motor vehicle is contrary to sustainability criteria. Policy options to reverse this include reurbanisation and the reorientation of urban transport networks towards shorter, multi-purpose trips.

The analysis of plans indicates that the policy options included in the Auckland Strategic Planning Model 1994 are consistent with the development of a more sustainable city. Option 1 in the Auckland Strategy Planning Model has the highest level of compatibility, based on criteria regarding land use, urban form and urban design. More than 90% of policies relating to environment and transport viability and 100% policies regarding land use and urban design are consistent with sustainability criteria. Of the 22 criteria identified in the literature, 15 are satisfied by the these policies.

CHAPTER 8
SUMMARY OF CONCLUSIONS

8.1 SUMMARY

Urban areas provide the structure through which we interact with the environment, both built and natural. This interaction is highly dependent on the urban form and the life styles it facilitate within the city. The aggregated patterns of land use and transport as they are represented in different city layouts together with ideas of regional ecological planning and concentrated decentralisation, can be studied to provide insights into sustainable city layout. New approaches to planning can also emphasise the urbanity, diversity and vibrancy of socio-economic, and cultural values in urban areas.

Some of the great planning visionaries advocated decentralisation of population away from cities as the way of improving urban life. However, modern city planning approaches call for a new design synthesis for cities, suburbs, and even solar villages. The Friends of the Earth (1993), for example, argue for a new approach to urban planning based on concepts of decentralised concentration and high density mixed land-use. Ironically, the phenomena of mixed-use, decentralised concentration and high density are equally characteristic of ancient walled cities, built well before the modern era.

The Utopian proposition of developing Garden Cities by building new dormitory towns near existing cities implied that when the population grew, there would be plenty of open land in which to locate new suburbs in a rural environment at various nodes of the highway networks. The vision emphasised the need to relocate the population away from the unpleasantness of industry, commerce and congestion. The basic tenet was the need to start growing new towns from small settlement units on new sites and creating an urban environment more closely connected to the natural environment. New towns or suburbs remained dependent on the nearby city or "mother" town for employment opportunities, and specialised civic amenities, including hospital facilities. This dependence on urban facilities required a substantial transportation network, particularly with the advent of motorised traffic.

This form of low density, dispersed development is highly inefficient in terms of energy and resource use, especially where people depend on private transport for most of their activities. Another

drawback to the Garden City concept is implementation. The Garden City concept was promoted as an alternative to conventional large cities and disregarded the benefits a big city user would get through access to specialised urban facilities. In a concentrated urban area, most of the infrastructure costs are shared by various land-use activities. This is not the case in Garden Cities. The only advantage of Garden Cities is that they are environmently efficient settlements.

On the other hand, linear cities fostered higher densities, but in isolation from the main urban centres. They represent urban form based on extravagant uses of natural resources. Satellite cities fostered the development of highway networks, which were dependent on the mother town for urban facilities and employment, shopping and other amenities. Although satellite cities were developed on the principle of self sufficiency and socio-economic sustainability, this did not happen in practice and encouraged urban sprawl.

A significant shift in city planning was brought about by Le Corbusier who proposed high-density residential and office building, based on medium-rise apartment blocks, and high-rise skyscrapers. High-density residential blocks were to be the means of improving internal communications and increasing the amount of open space within the city. He pointed to a significant shift from the development of sprawling development calling for expensive highways towards high-density and multi-storey development, without sacrificing the open space favoured by earlier design principles, despite the major shift implied from the decentralised, dispersed Garden City or Satellite town.

The challenge today is for urban planners to reconcile ideal design within existing city form, and so meet the demands of sustainability. Alternative courses of urban development may have to be adopted in different localities if sustainability is to be achieved. The new development approach may be based on a fundamental reappraisal of resource use, especially in the areas of energy, transportation and land.

The "megaform" and suburban Solar Villages are the new versions of the nineteenth-century frontier towns. Such communities might ride the ocean currents, extracting energy from the sun, and food and raw materials from the sea. In these proposals, less attention is paid to location, shared amenities, sense of community, permanence, long term costs, or even broader definitions of sustainability. They still depend

on mobility through use of the private vehicle between settlements, with the Garden City as a guiding model. These new plans are technically possible, but costly and complicated and can raise many difficulties when implemented.

Modern suburban layouts have been developed on the principle of private ownership and social equity. These layouts are different from the original Utopian city and new town approaches, which highlighted free-standing status of suburban scale communities, and could lead to a sense of isolation. Modern values instead, encouraged suburban development within the metropolitan areas. These traditions of planning included the focus on automobile dependant development, and the diverse city form advocated by Lynch (1981). The shifts in this history took place not just in terms of urban form, but also through accompanying institutional and values changes.

The emphasis of modern planning approaches is on balancing interaction with the natural environment by way of deconcentration and dispersal, with dense urban concentration, or concentrated decentralisation. This emphasis demonstrates and relies on the relationships between urban planning, urban form and urban sustainability. The important focus is on identifying ways of moving towards urban sustainability.

Sustainability implies that urban development sustains present needs without compromising the needs of future generations. Sustainability has opened a debate within and between different disciplines. Some have defined sustainability in a regional development sense. Others emphasise the impossibility of urban sustainable development, given the flows of resources, pollution and waste across boundaries.

It is not easy to make and implement policies which go against well-established trends in land use, transport and urban forms. It is difficult simply to stop the suburban growth trend which has been a dominant urban force since 1945 in most western countries without bringing about major behavioural changes. An alternative planning approach may be one that achieves a balance between compactness and decentralisation, having regard to environmental and other objectives. This would appear to correspond to decentralised concentration as a basis for settlement planning, a form of urban development proposed in different forms by Owens; Orrskog and Snickars; Breheny; and Van der Valk.

The sustainable urban forms of the future will have to be derived largely from our existing buildings and urban systems even though the forms of existing cities are significantly different from those of the past. Planning changes involving low risk and high acceptability may be the most appropriate. Conservative criteria for land use and urban form, transport viability, behavioural change and design of built environment should help to guide future city planning. It will be important to take account of the empirically estimated energy efficiency of different urban layouts and transport networks as advocated by urban designers, such as Keven Lynch (1981), Rickaby (1994), Steadman & Barret (1991), and Newman & Kenworthy (1989).

Another option for the modern city may be to control urban sprawl and encourage development that is less automobile dependent through the reorientation of transport based on planned congestion. Planned congestion can help a city to progress towards lower car dependency and lower energy use through a better balance between public transport, walking and cycling. Planned congestion could offer an opportunity to help contain the outward growth of cities. It supports more efficient, shorter travel distances, give priority to public transport, and fundamentally lowers automobile dependence and the transport energy use in urban areas. Again, it depends on and complements appropriate urban form, urban form which makes alternative modes viable.

During the decades from the 1950's to the 1980's, transportation plans were developed on the principles of efficiency and speed, thereby encouraging urban sprawl. However, transport planning today has to be in a framework which provides for sustainable urban form and environmental quality as a higher priority than has been the case in the past. Among other things, this has to be followed by a change of priorities in transportation policy towards more public transport.

The relationship between transport energy consumption and income is not simply a function of car ownership. It is also affected by changing patterns of land use associated with income and wealth. Studies of the relationship between energy consumption and land use attempt to assess how different urban forms may affect the amount of energy used. The following guidelines may help reduce the energy consumption:

- Reduction in the travel distances and trip rates so that residential areas can be related to local jobs and services and not developed as dormitory suburbs

- Reduction in the physical separation of activities to decentralise some jobs and services and relate them to residential areas within a single node or large urban area
- Formation of freestanding settlements which may or may not retain links with the original city centre
- Greater diversity of land use within the built areas, based on the belief that concentration of new developments in smaller centres outside the urban area is less costly and more effective because of reduced levels of traffic congestion and the greater availability of space
- Encouraging heterogenous land use patterns
- Developing nodes within major arterial routes diverging from the city centre
- Encouraging residential densities of more than 28 persons per hectare and the suburban density of 6-10 persons per hectare.
- Reducing infrastructure costs and operating costs with proper designs of physical infrastructure, and open up the opportunity for a level of social interaction that transcends the isolation of low density suburbs
- Adopting information-efficient and energy-efficient criteria through building location and orientation, passive solar heating and cooling, day lighting and shared use of capital-intensive facilities
- Balancing population and job opportunities within each city block
- Developing a medium and high density city block having a population between 10,000 and 40,000 in each city block
- Limiting population in major urban areas according to the available facilities

This set of guidelines does not make any particular assumption about the nature of activities within the new centres, but focuses on the impacts of urban scale. It implies:

- that low density cities are less fuel efficient because of congestion and land use separation
- that there is also a strong relationship between vehicle ownership and urban form. Car use declines as cities become denser, more compact and centralised.

High densities and centralisation of different activities appear to be clear factors which determine the viability of public transport and thus support a less automobile-dependent city. Public transport in the

form of a bus or rail systems in big urban centres can increase fuel efficiency. More walking and cycling can bring about change in fuel consumption in urban areas.

The review of transport and land use characteristics for Auckland is indicated that:

- The number of dwellings in the Auckland urban area increased by 11% between 1986 and 1991 while the number of jobs decreased by 3%
- Car ownership increased from 1.4 to 1.5 per household from 1986 to 1991
- The number of vehicle trips in Auckland increased by 77% between 1963 and 1973 and 64% during 1973 and 1992
- Person trips increased 67% between 1963 and 1973 and 34% between 1973 and 1992
- The number of trips per person has also increased quite rapidly from 1.2 per day in 1963 and 1.4 per day in 1973 to 2 per day in 1991 (ARLTS, 1994).

Increased trip making is not only due to the increase in car ownership but also a result of more overall trips. This reflects the facts that people have changed their living style and have become highly dependent on car use and that areas have been developed within the city with only limited public transport. These trends also reflect the fact that people are living further from their place of work within the Auckland Urban Area. Auckland has much low-density housing which has arisen partly as a result of the availability of cheap land, market pressures and personal choice. A declining city centre as a result of the development of satellite centres serviced by the private car has been the case.

The evaluation of past and current planning trends in Auckland suggest that future planning will be limited to marginal development. Increasing the density of population is a slow process. However, density increases and the development of a strong city centre are ways to increase energy efficiency.

Restrictive planning to achieve such increase is long term but one of the possible policy options. More immediate policy options could focus on reurbanisation and reorientation of the urban transport network for shorter and multi-purpose trips.

Five different transport plans and the four policy options from the Auckland Strategic Planning Model were assessed against criteria organised according to the following key elements of sustainability:

1. land use and urban form;
2. transport viability;
3. behavioural change; and
4. design of the built environment.

The most recent plans have shown a major shift from a development approach to a sustainability approach. The policy options included in the Auckland Strategic Planning Model 1994 are mostly consistent with the criteria for sustainability.

8.2 CONCLUDING COMMENTS

This research has shown that:

- Auckland has all the characteristics of the wealthy industrialised cities
- Auckland has a declining city centre as a result of the development of suburban centres serviced by the private cars
- incremental development on the city edge has been the over riding form of development since 1950's
- the number of dwellings, car ownership, vehicle trips and the number of trips per person has increased rapidly in Auckland since 1950's
- the over riding emphasis has been on private transport since 1950's transport and land use planning
- the focus of the past plans was on urban extension and actually to increase dependence on private transport and reduce it on public transport
- minimum attention has been paid towards the development of public transport
- more recent planning is shifting in the direction of sustainability. It remains to be seen whether this shift is reflected in future planning practice.
- despite falling percentage, the increased use of public transport identified in earlier plans, remains an impartial way of achieving sustainability.

A new approach for urban living has to be investigated which can satisfy human needs, the desire for self-fulfilment, and improved environmental development. This requires active planning and conservation of natural resources. For the greatest chance of success, it must also:

- minimise overall changes from existing city development patterns
- minimise impacts on resource use
- minimise public capital and physical development costs
- the pursuit of community well being
- limit the chances of failure
- achieve high levels of acceptability
- minimise public intervention

Gradual changes within the current metropolitan limits of Auckland may be most appropriate in terms of urban sustainability. The policy option suggesting least change in existing development trends may be the most likely to succeed. The advantage of adopting such a policy option would mean minimum public intervention, lower risk and high level of acceptability.

Bringing about major changes in urban form would require a high level of public intervention, public capital and private sector costs. It could impact adversely on community well being and is likely to have the least level of acceptability. Market will react against it to protect their interests and investments.

The right direction for Auckland urban area is to develop and implement policy options which:

- improve in public transport, including bus and rail systems, and encourage its use.
- promote reurbanisation, urban containment and selective intensification within current metropolitan limits
- pursue selective intensification at the urban nodes which have reasonable potential for becoming self contained urban catchments within existing metropolitan limits.

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