Framing out Urban planning and Policy Tools to the Problem of Air Pollution and Climate Change: Developing an Integrated Policy Framework Model

By
MUHAMMAD SALAHA UDDIN (737141)
msupavel@yahoo.com

Session: 20010-2011

Master of Science thesis submitted to the School of Architecture and Society, Politecnico di Milano, Milan in partial fulfillment of the requirement for the degree of MSc of Urban Planning and Policy Design.

Politecnico Di Milano,Milan,Italy.

December, 2010.

CERTIFICATE OF APPROVAL

Framing out Urban planning and Policy Tools to the Problem of Air Pollution and Climate Change: Developing an Integrated Policy Framework Model

By
MUHAMMAD SALAHA UDDIN (737141)

Session: 2010-11

Thesis Approved as to the style and Content by

Signature of the Supervisor ______________________________

Eugenio Morello,
Assistant Professor
Dipartimento of Architettura E Pianificazione (DiAP)
Milan, Italy.

December, 2010.

Acknowledgement

At first, all praises belong to Almighty Allah, the most Merciful and the most Beneficent to man and his action, who provides with me the opportunity to conduct this study and to submit this thesis report.

The study has been carried out under the direct supervision of Late Professor. Faustino Curti and Eugenio Morello, Dipartimento Di Architettura E Pianificazione (DiAP), Politecnico Di Milano, Milan, Italy. I would like to express my profound gratitude and indebtedness to them of their constant supervision, continuous guidance, invaluable suggestions and unfailing encouragement given throughout the study.

I would like to thank those who encouraged me to study up to this level. To my parents who are living in Bangladesh, I say thank you for your parental sacrifice which enabled me to study in Italy. Special thanks to my beloved elder brother who helped me in concept generation level by giving his professional views and suggestions about the issue.

I am thankful for cooperation and assistance extended by the staff of the Central Library of Architecture and Society, Politecnico Di Milano, Milan. I owe special thanks to my friends Md.Shakil bin Kashem and Farjana Lisa who are studying in University of Illinois at urabna Champaign, USA and University College London, UK respectively for their assistant to collect some articles from different journals.

I recall the unforgettable mental and leisure support from all Bangladeshi students during the study period in Italy, without their companionship it would be difficult to continue the study in abroad.

All other people who assisted in various capacities, I render my profound gratitude to them.

Finally, I dedicate this thesis of mine to my dearest Parents.

ABSTRACT

The issue of climate change and air pollution is a matter of integration due to the interaction at their happening and impact creation. In this study this impact on each other is analysed and compared at urban setting. Based on this influence characteristic two dimensions are considered to fix up the urban planning and policy tools to mitigate and adapt the problem of climate change and air pollution. The listed urban planning and policy (UPP) tools are discussed under these two dimensions: one is emission control dimension and another one in effect adaptation dimension. Emission control dimension are again considered as direct and indirect ways to mitigate the emission of Green House Gas (GHGs) and pollutants. Among the emission control planning and policy tools urban density, urban spatial form, urban design aspects, Floor area Ratio, Zoning, Transport oriented development, Travel Demand Management and livelihood improvement strategy are discussed as indirect emission control tools. On the other hand as direct emission control tools development mitigation fee and emission density zoning are listed and discussed.

It is found that the most of the indirect emission control tools can be applied to control the emission by reducing the energy consumption. The major effect of all those tools is observed in transportation sector and to change in human behaviour. Compact and high density development is considered as positive factor to reduce the energy consumption at urban scale. On the other hand there are some trade off functions between urban density and other urban functions. Urban spatial form is another very important planning tool that can be used for new developed area. But it is also considerable for built up city to realize the energy consumption and emission rate and pattern influenced by spatial setting of the city. Urban design aspects, FAR and zoning are basically operational tools that help to gain certain objectives and to ensure environmental friendly development in city that can reduce the emission. On the other hand Travel Demand Management (TDM) and Transit Oriented Development (TOD) are primarily the part of transport planning and their objects are to promote certain use and control the mobility in guided ways. Livelihood improvement is related with the economics and physical living environment that can also help to reduce the air pollution and GHG emission at city level. As direct tools mitigation fee and EDZ are discussed as regulatory tools for direct control on emissions.

The second dimension of the integrated problem is effect dimension. It is observed that at city level only urban heat island (UHI) is an effect dimension of the climate change and air pollution. To adapt this problem different tools are discussed under three broad categories: anthropogenic heat reduction, surface coverage improvement and structural improvement. Based on the analysis of all tools finally a common policy framework is developed. The framework developed with three basic features that are urban system optimisation, urban growth management and urban development compensation.

Finally how this framework can workable in a specific context is analysed. In this case Dhaka is selected as case study and only effect dimension are analysed to see the applicability of the listed tools. It is shown that specific policies concerning building delivery and urban drainage system can help to apply the listed tools and to adapt the problem of UHI in case of Dhaka

Sommario

La questione del cambiamento climatico e l'inquinamento atmosferico è una questione di integrazione a causa della interazione a loro accadendo e la creazione di impatto. In questo studio tale impatto su ogni altro viene analizzato e confrontato al contesto urbano. Sulla base di questa caratteristica influenza sono considerate due dimensioni per sistemare la pianificazione urbana e strumenti di politica di mitigazione e adattamento al problema del cambiamento climatico e inquinamento atmosferico. La pianificazione urbana di cui la politica (UPP) strumenti sono discussi in queste due dimensioni: una dimensione è il controllo delle emissioni e un altro nella dimensione effetto di adattamento. dimensione di controllo delle emissioni sono ancora considerate come mezzi diretti e indiretti per mitigare le emissioni di Green House Gas (GHG) e di inquinanti. Tra la densità delle emissioni pianificazione del controllo e degli strumenti di politica urbana, urbano forma spaziale, aspetti di progettazione urbana, Superficie Ratio, Zonizzazione, orientata allo sviluppo dei trasporti, gestione della domanda di viaggio e di miglioramento della strategia di mezzi di sussistenza sono discussi come strumenti indiretti di controllo delle emissioni. D'altra parte come diretta quota di controllo delle emissioni di mitigazione strumenti per lo sviluppo e la densità delle emissioni zonizzazione sono elencati e discussi. Si è trovato che la maggior parte degli strumenti indiretti di controllo delle emissioni può essere applicato al controllo delle emissioni, riducendo il consumo di energia. L'effetto principale di tutti questi strumenti è osservato nel settore dei trasporti e ai cambiamenti nel comportamento umano, Compatto e di sviluppo ad alta densità è considerato come fattore positivo per ridurre il consumo di energia a scala urbana. D'altra parte ci sono alcune funzioni di trade-off tra densità urbana e altre funzioni urbane, forma spaziale urbana è un altro strumento di pianificazione molto importante che può essere utilizzato per le nuove superfici di sviluppo. Ma è anche notevole per costruire città a realizzare i consumi energetici , il livello delle emissioni e il modello influenzato da l'impostazione spaziale della città, aspetti di progettazione urbana, FAR e la zonizzazione sono fondamentalmente strumenti operativi che consentono di ottenere determinati obiettivi per garantire lo sviluppo ambientale amichevole in città che possono ridurre le emissioni. D'altro canto Travel Demand Management (TDM) e Transit Oriented Development (TOD) sono principalmente la parte della pianificazione dei trasporti e sono oggetto di promuovere l'uso certe di controllo della mobilità in modo guidato,il miglioramento Livelihood è collegato con l'economia e ambiente di vita fisico che può anche contribuire a ridurre l'inquinamento atmosferico delle emissioni di gas serra a livello di città.Come strumenti di pagamento diretto di mitigazione EDZ sono discussi come strumenti di regolamentazione per il controllo diretto sulle emissioni. La seconda dimensione del problema è integrato dimensione effetto, Si osserva che a livello di città unica isola di calore urbana (UHI) è una dimensione dell'effetto del cambiamento climatico e inquinamento atmosferico. Per adattare questo problema si sono discussi diversi strumenti in tre grandi categorie: riduzione del calore di origine antropica, la copertura della superficie e il miglioramento strutturale. Sulla base dell'analisi di tutti gli strumenti finalmente un quadro politico comune è sviluppato. La struttura sviluppata con tre caratteristiche di base che sono: l'ottimizzazione del sistema urbano, gestione della crescita urbana e urbanistica sviluppo di compensazione, Infine come questo quadro può essere realizzabile in uno specifico contesto, viene analizzato In questo caso Dhaka è selezionata come caso di studio e dimensione effetto, solo vengono analizzati per vedere l'applicabilità degli strumenti elencati. Si dimostra che le politiche specifiche in materia di consegna dell'edificio e il sistema di drenaggio urbano può contribuire ad applicare gli strumenti elencati e ad adeguare il problema della UHI in caso di Dhaka(citta').

Table of Contents

List of Table:

List of Figures:

List of Boxes:

Abbreviations

°C	:	Degree Celsius
AP	:	Air Pollutants
CO	:	Carbon Mono Oxide
CO_2	:	Carbon Di Oxide
CLHI	:	Canopy Layer Heat Island
CBD	:	Central Business District
BLHI	:	Boundary Layer Heat Island
DAP	:	Detail Area Plan
EDZ	:	Emission Density Zoning
FAR	:	Floor Area Ratio
GHG	:	Green House Gas
IPCC	:	Intergovernmental Panel on Climate Change
ISR	:	Indirect Source Reduction
LUTAQH	:	Land Use ,Transportation ,Air Quality and Health
NOx	:	Nitrus Oxide
PM	:	Particulate Matter
SOx	:	Sulfher Oxide
TDM	:	Travel Demand Management
TOD	:	Transit Oriented Development
UDD	:	Urban Demographic Density
UCL	:	Urban Canopy Layer
UHI	:	Urban Heat Island
ULD	:	Urban Land Use Density
UPP	:	Urban Planning and Policy
URD	:	Urban Resource Density
VHT	:	Vehicle Hourly Travelled
VMT	:	Vehicle Miles Travelled
VOC	:	Volatile Organic Compound

Chapter-I

Context and Concpet Generation

Chapter I
Context and Concept Generation

Key Words: Air Pollution, Climate Change, GHGs Urban Planning and Policy (UPP) Tools

This chapter is developed as a way to generate the general concept of the basic topics of the study. In this study there are three basic terms that will be used throughout the study. The terms are air pollution, climate change and urban planning and policy (UPP) tools. At the beginning of the chapter the context of climate change and air pollution will be depicted. Then as a way to relate the concept of UPP tools with the problem of climate change and air pollution will be analysed. After that study objective, organization of the study and limitation of the study will be discussed in order.

1.1 Scenario of Climate Change and Air Pollution

Climate change is the most important issues in today's technological and industrial activity based productive world. It is considered as a global problem due to the global problem of rising global temperature, sea level rise, and dramatic changes in weather patterns. The severity of climate change varies according the geographical location of the area. Some places of the earth are more vulnerable than the other parts of the world from this climatic expression. The scenario of climate change over the world is depicted by the Intergovernmental Panel on climate change (IPCC). In its fourth assessment report, 2007 the issue of climate change are addressed from different angles. Some very basics and preliminary are addressed here to conceptualise the scenario of the climate change in the world. The global mean temperature has up to 2005 risen by almost .8°C and the change expected by 2100 is as large as glacial-interglacial changes in the past, which were commonly spread out over 10000 years. The release of CO_2 gases in earth's atmosphere are considered as one of the main causes of global climate changes. Atmospheric CO_2 has now reached levels unprecedented during the past several million years. Principal threats are greatly reduced biodiversity (species extinction), changes in the atmospheric precipitation pattern, more frequent weather extremes and sea level rise.

Air quality and air pollution has become an increasingly an urban problem throughout the world as urbanization and industrialization have intensified during the last few decades. More than 3 billion people—about half the world's population—are now concentrated in urban areas, and by 2010 the global urban population is expected to swell to more than 4 billion (UNEP, 1999).

By one estimate, more than 1 billion people are currently exposed to harmful levels of air pollution (Schwele, 1995). Severe particulate air pollution is a chronic problem in much of Asia, primarily as a result of coal combustion in factories and power plants, and the use of coal and wood for cooking and home heating. Motor vehicles are an increasingly important contributor to air pollution in much of the world, with more than 600 million vehicles in use, a number that could double within the next 25 years (Dunn, 1996). Automobiles are the dominant source of air pollution in many Latin American cities, including Sao Paulo, Santiago, and Mexico City, where they have had to restrict automobile use in an effort to manage severe air pollution episodes (UNEP, 1999).

U.S. air quality, as measured at thousands of monitoring stations across the country, has shown steady improvement over the past 20 years due in part to the implementation of air quality regulatory programs and cleaner technologies for motor vehicles and stationary pollution sources. There are, however, still many areas of the country that are not in compliance with ambient air quality standards for pollutants such as ozone and PM (EPA, 1999).

In such a global scenario of these two problems of air quality the urban area become the prime focus for the solution of the problems. The causes and effects of these two problems are mostly centred from urban area. It is always believed that where the problem generates the solution also exists there. On the hand the effects of any problem should always be treated in its receptor. From this realization the study is conducted to find out the urban planning and policy tools against the problem and how the application of those tools can be applicable under certain context.

1.2 Scope of Urban Planning and Policy Tools against Climate Change and Air pollution

Addressing climate change and air pollution and their integrated effects at city level through urban planning presents a twofold challenge: On one hand “mitigation”, that is limiting further climate change and air pollution by reducing the production of greenhouse gases and emission of air pollutants; and, “adaptation” on the other hand, which is about preparing for the impacts of inevitable climate change. Urban planning could play a key role in minimizing climate related risks in the human environment. Moreover there are many opportunities to use knowledge in the urban planning process to reduce greenhouse gas and emissions of air pollutants. It is essential that climate change and air pollution be tackled in an integrated way in developing and practicing urban planning and policy.

It is evidenced from the Inter governmental Panel on Climate Change (IPCC) assessment report 2004 that worldwide different sectors have different level of contributions to the GHG emissions. Three sectors of GHG emission are waste and wastewater, transport, residential and commercial buildings (altogether 24%) can directly be influenced by urban planning tools in the way to mitigate the GHG emission and climate change adaptation.

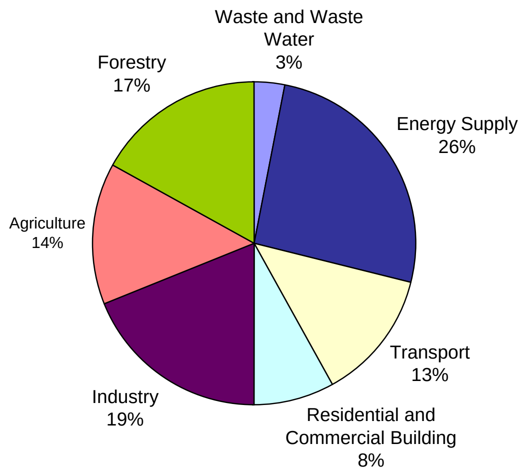


Figure 1.1: Global Anthropogenic GHG Emissions By Sector (2004)
Source: IPCC Assessment Report 4 (2007),Summary of Policymakers: Figure SPM3
**Forestry Includes Deforestation*

In an another report it is also addressed that smart land use and transportation can reduce 27 % GHG, from buildings and appliances sector is possible to reduce 7%, from vehicles and fuels sector 41.2% while from waste management 6% GHG can be reduced in case of Calfornia (CAPCOA, 2008). Newman and Kenworthy (1999) showed that travel concepts and urban from clearly correlate with carbon dioxide emissions. Moreover, urban efficiency is usually defined in terms of travel patterns, infrastructure networks and energy use as well as environmental costs including water use, congestion costs and the costs of sprawl (Kropp and Reckien, 2009). All of these issues are related with different sectors of urban planning and policy. Urban planning in a way can ensure the capacity of the existing and potential infrastructure (including for water supply, sewage and sewerage, waste management and community infrastructure such as schools and hospital) to service the site or area in ways consistent with cutting carbon dioxide emissions and successfully adapting to likely changes in the local climate. Although it is difficult to draw a relation of urban planning tools that can be used to reduce that amount of GHG, it is clear that urban planning and policy tools should have strong influence in reducing GHG.

On the other hand there are numbers of urban planning tools that help to reduce the pollutants and improve the air quality. The findings of several studies provide evidence that the shape of a city and the land use distribution determine the location of emission sources and the pattern of urban traffic, affecting urban air quality (Borrego et al, 2004). Compact cities with mixed land use provide better air quality compared to disperse cities with lower densities and segregated land use or network cities equipped with intensive transport structures. (Borrego et al, 2004). So in a very concrete way it can be said that the role of urban planning is to manage the spatial organization of the cities for the efficient allocation of urban infrastructure and land use. Depending on the way of application of urban planning it can improve air quality in the long run by strategic location of polluting sources and exposed pollution and encouraging a city structure that would minimize pollution emissions and build up (World Bank, 2002).

1.3 Urban Planning and Policy Integration

Urban planning and policy tools integration to face the problem air pollution and climate change means the mixing of structural and behavioural measures. In this case the aim is to find out the best practice in terms of cost effectiveness. Policies are the feed back that aims to control the effects of fossil fuel combustion (Raes, 2006). Policy can be varied from the domain of environment, economic and social. In different domains different policies can be generated targeting the issue of climate change and air quality control. On the other hand urban planning is usually done to promote efficient urban infrastructure and allocation of land use, thereby contributing to economic growth. Besides, urban planning is done to manage spatial extension and to minimize urban service providing cost, to improve and preserve the quality of urban and natural environment. So, both urban planning and policy are able to manipulate the urban system, structure and behaviours of the people. In case of climate change and air pollution this power of urban planning and policy can be issue of exploration. The study object will be to frame out planning and policy tools and to develop a common policy frame work.

1.4 Objectives of the Study

For the purpose of proper orientation and ensuring intended outcome of any study or research project it is necessary to set the objectives before the work is started. The Objectives are as follows:

a. Frame out urban planning and policy tools toward the GHG emissions and air pollutions problems;

b. Develop an integrated and structured policy framework for climate change and air pollution problem simultaneously.

1.5 Limitations of the Study

Like other projects or research works, this study also has few obvious constraints, difficulties and limitations. These problems may not be totally overcome but tried to mitigate as far as possible. Those limitations regarding the study are going to be discussed below:

Limitation of time

The study was conducted in a very short time. In order to complete a study successfully it is required to do the work in a very precise way which needs a very long time. But as the time is very short it was very difficult to carry out the study precisely and to go in depth analysis.

Limitation of relevant studies

The application of urban planning and policy tools to mitigate and adapt climate change and air pollution is not common and directive in practice. Most of the cases they are applied in different ways with different prime objectives. So, there are some limitations of exact and relevant study in this sector.

1.6 Organization of the Study:

The total study has been organized in seven chapters in different sectors. A brief outline of those chapters is given below

Chapter 1 represents the introduction and concept generation of the study. It contains the state of art of climate change, air pollution and logical background of the study alongside the importance it bears.

Chapter 2 provides the methodological and procedural approach that is followed to carry out this study. Further elaboration has been done under different headings.

Chapter 3 draws the general concept of air pollution and climate change. Besides, the influence scenario of Air pollution with general impact scenario of atmospheric expression of climate change is described. On the contrary how the air quality does become a matter of concern due to climate change is discussed

Chapter 4 holds the discussion on the urban planning and policy tools that can be applied against climate change and air pollution simultaneously.

Chapter 5 contains the discussion on integrated framework which can work as a solid base for the application of all listed tools. The basic features, component and logical relation of the framework are discussed in this chapter.

Chapter 6 presents an application context of the listed tools with the reference of developed policy framework in the case of city of Dhaka. Instead of discussion the all the available tools only the Urban Heat Island (UHI) adaptation tools are discussed in this chapter.

Chapter 7 which is the last chapter includes the conclusion of the study focusing to the findings of the study.

References

1. Borrego C, H. Martins, O. Tchepel, L. Salmim, A. Monteiro, A.I. Miranda (2004), How urban structure can affect city sustainability from an air quality perspective, Department of Environment and Planning, University of Aveiro, 3810-193 Aveiro, Portugal

2. CAPCOA: California Air Pollution Control Officers Association (2008). California Environmental Quality Act and Climate change

3. Dunn, S. (1996),Green Auto Racing. Natural Resources Defense Council, Washington.

4. EPA: Environmental Protection Agency (1999) National Air Quality and Emissions Trends Report. EPA report #454/R-00-003

5. IPCC, Climate Change (2007) – The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC (Cambridge University Press), ISBN 978-0521-88009-1 (2007a)

6. Kropp Juergen & Reckien Dianna (2009), *Cities and climate change which option do we have for a safe and sustainable future*

7. Newman P. & Kenworthy, J. R. (1999), *Sustainability and Cities: overcoming automobile dependence*, Island Press, Washington DC

8. Raes Frank (2006), Climate Change and Air Pollution- Research and Policy, *Global Change News Letter* No.65 March 2006.

9. Schwele, D. (1995), Public Health Implications of Urban Air Pollution in Developing Countries. Proceedings of the 10th World Clean Air Congress, Espoo Finland, 28 May – 2 June.

10. UNEP (United Nations Environment Program)(1999), *Global Environment Outlook*, Earthscan publications Ltd., London. 398 pp.

11. World Bank (2002), South Asia Urban n Air Quality Management Briefing Note No 6.

Chapter-II

Methodology

Chapter II
Methodology

This chapter deals with the procedural approach that was followed to carry out the study. There are some differences between the theoretical approach to work and the actual methodology which was applied to accomplish the study. In compliance with the fact, this chapter is designed to illustrate the methodology approach that was followed in accomplishing the study. The study is a literature based study. The methodology of the study is presented here in different stages and under the following headings.

2.1 Scientific Understanding of Climate Change and Air Pollution

At the beginning of the study the attempt was given to understand the scientific basic of climate change and air pollution. Air pollution and climate change are the two problems that are taking places at different levels. From this consideration this understanding exploration was carried out. At this stage the individual happenings of climate change and air pollution was studied. In fact this stage was the concept generation stage. Based on this stage the next steps of the study were fixed. This was the base step of the whole study.

2.2 Identification of the Common Influence Nature of the Climate Change and Air Pollution

In this step the influence nature of the climate change and air pollution was identified. The object is to find out the way of influence and base on this the linkages of urban issues were framed out. In case of identification of the influence different scientific research paper were gone through. Some differentiated findings were found in different papers. Beyond the existing scientific complexities the influence relationship of climate change and air pollution was tried to depict in a very simple way. This step is the foundation to listing the common urban planning and policy tools.

2.3 Identification of Common Source/Causes and Drivers

This step is the continuation of the previous step. As the idea was to frame out the urban planning and policy tools the focus was given to find out the common source/causes and drives of climate change and air pollution in relation with the influencing nature in urban area.

2.4 Identification o Urban Planning and Policy Tools

This is the most important stage of the study. In this stage different tools are identified based in the findings from the previous steps. In this stage each tool was analysed in depth to depict their way of working against the problem of air pollution and climate change. Numbers of tool were identified in this stage and in case of selecting those tools the care was given about their applicability in an urban area.

2.5 Fitting Identified Urban Planning and Policy Tools in Sectored Framework

Based on the analysis of each tool common policy domain of each tool was fixed. In this stage it was tried to develop a crispy set of the identified tools under the specified policy domain. To do this the major influential force of each tool in case of solving the problem of climate change and air pollution was considered. The interaction and inter linkages among the different tools are also analysed in this stage.

2.6 Develop Policy Framework of Urban Planning and Policy Tools

This was the last and final stage of the study. In this stage the identified policy domain of the listed tools were analysed in terms of their interaction within the extended policy domain. At this stage the idea was to fix up a framework of UPP tools against the problem of climate change and air pollution. A framework policy domain will be helpful to apply those listed tools in real field application with other policies.

2.7 Real Context Analysis to Test the Developed Policy Framework

This stage is the extended part of the study. It was no possible to cover the whole UPP tools to test in the application level under the developed policy framework. Only the impact dimension of climate change and air pollution was analysed to depict the situation. As case study, Dhaka (Capital City of Bangladesh) was selected to test the situation. The aim of this extended part of the study was to analyse the developed policy framework in real situation. To do this some significant features are discussed that are influential in terms of applying the listed UPP tools. This stage acts as the evaluation process of the developed framework. Addition and subtraction of new tools and interrelated domain fixation of each tool can be reorganized based on this extended part of the study. In the methodological flow chart the orderly relationships among the different steps are shown.

In the following the procedural steps of the study is given in a flow chart:

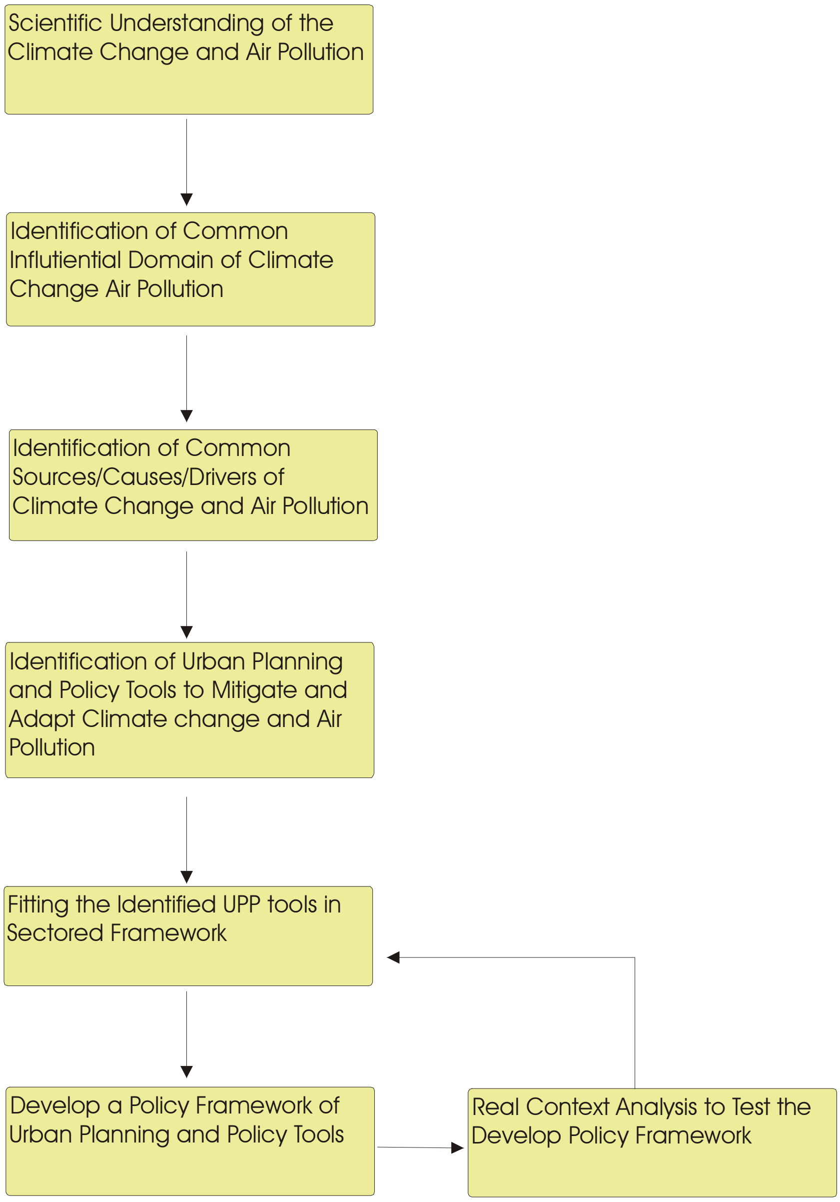


Figure 2.1: Methodological Flow Chart of the Study

Chapter-III

Integrated Influence Scenerio Analysis of Climate Change and Air Pollution

Chapter III
Integrated Influence Scenario Analysis of Climate Change and Air Pollution

Key Words: Air pollutants, Emission, Climate Change Impact

The impacts of climate change at city level have diverse nature and context oriented. In different contexts the impacts of climate change have different dimensions. Apart from the context and relevant impact analysis the focus will be given to embody the general atmospheric expression of climate change and their impact on built environment at city level. With this, the effort will be to draw the influence scenario of Air pollution with general impact scenario of atmospheric expression of climate change. On the contrary, how the air quality does become a matter of concern due to climate change will be discussed.

In today's science and environment the issue of climate change is a burning one. The impact of climate change has the basic focus to the physical content and expression of the atmospheric condition. In this impact scenario development process the discussion will be carried out based on the impact of atmospheric condition and later the probable impact on built environment at city level due to the conditional changes in atmosphere. The root of climate change is in the alteration of atmosphere. The composition of atmosphere is changing due to the impact of GHG. The changes in atmosphere have likely influenced temperature, precipitation storms and sea level (IPCC, 2007). In the following the nature of this influence is discussed in different levels and how are these atmospheric influences aggravated due to air pollution and vice versa. At the beginning the chapter is started by giving the basic concept of Air pollution and climate change and their common domains of interaction.

3.1 What is Air Pollution?

In a very general way the air pollution can be defined as the presence of air pollutants that come from a variety of sources such as industries and our vehicles, and can have significant direct and indirect impacts on our health, the environment and the economy. The world health organization has defined air pollution as substances put into air by the activity of mankind in concentration sufficient to cause harmful effect to his health, vegetables, property or to interfere with the enjoyment of his property. Engineer's Joint Council for air pollution and its control USA defined air pollution as: Air pollution means the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes gas, mist odour, smoke or vapour in quantities, of characteristics and of duration, such as to be injurious to human, plant or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property (Srivastava, 2009). These impacts may be experienced in the area near the source or sources of pollution. Alternatively, some pollutants can be transformed great distance by the wind, even across. This type of transfer of air pollutants is known as transboundary air pollution. The effect scale of air pollution varies from local to regional and sometimes global.

3.2 What is Climate Change?

The issue of climate change is broadly addressed in different literatures. Climate change is considered as an issue at global, regional and local level. In a simple way the term can addressed as a process of alteration of historical climatic behaviour over the period in global and local context. The consequences of climate change at city level have its instant and gradual impacts and also the predictable impacts. According the Ecology Department of Washington - "Climate change" affects more than just a change in the weather, it refers to seasonal changes over a long period of time. These climate patterns play a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them (DOE Washington, 2010). Climate change can be caused by a natural process such as the change in the sun's strength, and also by human activities, in particular those that alter the chemical composition of the atmosphere through the build up of green house gases (EC, 2010).

As many systems are tied with climate the change in climate can affect those systems as an component of the entire system or as an external factor of the system.

3.3 Common Domains of Air pollution and Climate Change

Usually air pollution is differentiated into three broad categories: ambient, indoor, and transboundary. Ambient air refers to the air close to the ground that is in direct contact with the living world; indoor air pollution refers specifically to air within buildings, whether at the workplace or in the home; and transboundary air pollution is used to refer to pollutants that have entered the upper atmosphere and travel far from their source. Air pollution of all three types is strongly affected by climate—precipitation, wind, temperature, radiation—and thus by changes in climate or "climate change". At the same time, air pollution is thought to be one of the major contributors to the present situation of "climate change". So, there exists a scientific relation in their way of taking place.

Climate change and air pollution are closely linked, although in applied scientific research and even more in political negotiations they have been largely separated. Many of the traditional air pollutants (APs) and greenhouse gases (GHGs) have not only common sources, but may also interact physically and chemically in the atmosphere causing a variety of environmental impacts on the local, regional and global scales (Bytnerowicz et al,2007).

There are important linkages between emissions of air pollutants and climate-relevant gases. These linkages exist because: (i) air pollutants have a radioactive forcing too (ii) air pollutants and greenhouse gases have common sources (iii) control of air pollutants and greenhouse gases result in joint benefits (IIASA, 2004).

In recent years it has been increasingly recognised that air pollution and climate change are linked in several ways and they could be beneficially addressed by integrated policy (Swart et al, 2004).

The push for policy integration comes mainly from consideration of implementation costs (Raes, 2006). It is estimated that cost of reaching the 2010 air pollution objectives in the conventions Gothenburg Protocol could be reduced by at least 5 billion if European countries cut CO_2 in line with the Kyoto protocol (without CO_2 trading). Similar results have been found for China and Mexico (UNECE, 2010). This is particularly true in developed countries, where cheap air pollution control technologies are widely implemented and further reductions are likely to require structural and behavioural measures. In developing countries current economics growth and the supporting development of energy production systems, provide the opportunity to tackle air pollution and GHG emissions simultaneously (Raes, 2006).

The ancillary benefits from GHG policies in developing nations may be even more significant relative to the cost of these policies than those measured in the U.S and Europe because of lower existing levels of pollution control and lower efficiency in energy use in these countries (Burtraw and Toman, 1997). Hence, implementing climate policies, for example in order to achieve greenhouse gas (GHG) emissions targets, can significantly reduce the costs of meeting air quality targets and vice versa.

3.4 Impact Scenario of Climate Change with the Influence of Air Pollution

According to the Environmental Protection Agency (EPA, 2009) USA, recent climate change impacts are addressed in the physical environment of temperature, precipitation, storms, sea level changes and ocean acidification. In the following only the temperature and precipitation are discussed as they are influenced by the level of air quality in regional and local scale. The integrated city level impacts of those two influences of atmospheric changes will also be discussed in the following.

3.4.1 Atmospheric Influence: Increased Temperature

The influenced impact of atmospheric change is the increased world temperature. The temperatures are increased in different levels. Increased temperature is observed in surface level, tropospheric level. Since mid 1970s the average surface temperature has warmed about 1°F (EPA, 2009). The warming trend is seen in both daily maximum and minimum temperatures increasing at a faster rate than maximum temperature (IPCC, 2007). On the other hand tropospheric temperature is increased by .22°F near the surface and by.27°F in mid troposphere per decade within the period of 1958-2006 (NOAA, 2008). The casual relation of this increased temperature is diverse due to its multiple and complex factors. As a concluding remark of IPCC it is said that warming in global average surface temperature that has occurred since the mid-20th century is very likely a result of human activities (IPCC, 2007). This increased global temperature has diverse effects on different systems of the world. The expected rise in global temperatures will affect human health, comfort, life styles, food production, economic activity, and residential and migration patterns (IPCC, 1990).

This increased global temperature is influenced by the air pollutants aerosols. During recent years evidence has emerged showing that particles suspended in the air actually affect the radiation balance (EPA, Sweden 2009). The aerosols not only help to increase the temperature it has opposite impact to cool the climate. But the magnitude of this effect is about 30% of the magnitude of the warming effect of by CO_2 (EPA, Sweden 2009). In view of the fact that combustion is the major source of anthropogenic particles, soot, ozone and CO_2 changes in combustion will affect all its pollution components. In general, CO_2, soot and ozone are warming components, while most other particles cool the climate. According to the IPCC (2007), on a global scale soot and ozone will, produce combined global heating of about 0.8 W/m^2, while particles will have a cooling effect of about -1.6 W/m^2. IPCC (2007) assessed the total direct climate effect by aerosols to be

-0.5 ± 0.4 W/m^2. It should be noted that this includes both heating by soot and cooling by the particles. The heating by soot is estimated at about 0.2 ± 0.15 W/ m^2. Recently, reports have emerged that imply much greater heating by soot (Ramanathan and Carmichael, 2008). It should be noted that the uncertainties in the estimates for soot and particles are quite large while in theory it should be possible to balance emission reductions of soot, particles and ozone so that the resulting global climate impact is small. Regions with extensive soot emissions would probably experience a cooler climate if soot emissions were substantially reduced (EPA, Sweden 2009). But, without real inclusion of aerosols in the climate Model it is nearly impossible to interpret the casual factors for regional as well as global climate changes during the last century.

3.4.2 Atmospheric Influence: Precipitation

The impacts of atmospheric change on precipitation also have two directions. In some places of the world it is positive and in some places of the world it has negative impacts. According IPCC 2007, Precipitation has generally increased over land north of 30°N from 1900-2005, but has mostly declined over the tropics since the 1970s. Globally there has been no statistically significant overall trend in precipitation over the past century, although trends have varied widely by region and over time. On the negative way it has become significantly wetter in eastern parts of North and South America, Northern Europe, and Northern and Central Asia, but drier in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.

The resultant of this positive and negative force of global change on rate of precipitation is influenced by the air pollutants in micro scale. Air born carbon and particles usually causes the large reduction of solar radiation at the surface (-4.4Wm^{-2}) will result in reduced evaporation and in turn reduced precipitation. Of course this will be countered by increased precipitation from the GHGs warming. It is likely that the reduction in precipitation will occur in the tropics where the dimming is the largest and the increase in precipitation will occur in the extra tropics where the GHGs warming is larger than the tropical warming (Ramanathan and Feng, 2009).

Air Born Carbon's impact over Asia: regionally, Air Born Carbons may have played a very large role in the widespread decrease in precipitation in Africa and in South Asia (the Indian summer monsoon) and the widespread retreat of glaciers in the Hindu Kush-Himalaya-Tibetan region. The former is due to dimming and the latter is due to solar heating of elevated layers by Air Born Carbons. The best explanation for the precipitation reduction downwind of urban areas is the precipitation suppression brought about by the increased number of small particles in the atmosphere from pollution. (Jirak et al, 2006). So it is evidenced that with the global change the air pollution has significance influence in the changing rate of precipitation at regional and local level.

Table 3.1: Summary of the Discussion

Impacts due to atmospheric Changes of GHG	**Nature of Affects of Major Air pollutants on influenced impact of atmospheric change.**			
	NO_2	CO	SO_2	Particulate Matter (PM)
Increased Te mperature	No Direct Effect	No Direct Effect	No Direct Effect	Influence Positively and Negatively
Precipitation	No Direct Effect	No Direct Effect	No Direct Effect	Impact positively and negatively

3.4.3 Controlling Air Pollutants and Influence on Climate Change Impacts:

Controlling other air pollutants can positively and negatively affect the impact of climate change. On this issue a research was conducted by Ronald G. Prinn (2005) and his team under the joint programme on Science and Policy of Global Change. The findings of the conducted research are summarized in the following Table:

Table 3.2: Air Pollutants and Influence on Climate Change Impact

Controlled Pollutants	**Impact Components of Climate Change**					
	Sulfate Aerosols	OH	O_3	CH_4	Temperature	Sea Level
Capping* SO_x	Decrease	Increase	No effect	No Effect	Increased highly	Rise Highly
Capping* NO_x	No Effect	Decrease	Decrease	Increase	Slightly Increase	Negligible Rise
Capping* CO and VOC	Increase	Increase	No Effect	Decrease	Small Decrease	Negligible Decrease
Capping* NO_x,CO and VOC	No Effect	No Effect	Decrease	Increase	Decrease more than the previous one	Decrease more than the previous one
Capping* all emissions	Decrease	No effect	Decrease	Increase	Increase** (less than the case of SO_x cap)	Increase** (less than the case of SO_x cap)

* For capping the air pollutants Emissions they used the emission level of 2005, whereas CO_2 emissions are predicted for 2100. They have done this experiment at global level, northern hemisphere and southern hemisphere. Here only the global level results are depicted.

** The increasing trend seems very antic. But the writes explains as the effect of increasing rate CO_2.

From the table it is understandable that Placing caps on SO_x leads to lower sulfate aerosols, less reflection of sunlight back to space by these aerosols (direct effect) and by clouds seeded with these aerosols (indirect effect), and thus to greater radiative forcing of climate change due to solar radiation. Enhanced radiative forcing by these aerosol and CH4 changes combined leads to more warming and sea level rise. On the other hand placing caps on NO_x alone also leads to decreases in OH and thus increases in CH_4. These OH decreases and CH4 increases are lessened (but not reversed) when there are simultaneous NO_x, CO and VOC caps. Increases in CH_4 lead to greater radiative forcing. In general, placing caps on NO_x alone, or NO_x, CO and VOCs together, leads to lower ozone levels, and thus less radiative forcing of climate change by this gas. Hence these impacts on climate of the pollutant caps partially cancel each other.

3.5 Impact Scenario of Air Pollutants with the Influence of Climate Change

The term air pollution has local, regional and in some cases global dimensions. The non local process of air pollution is affected by metrology and thus by climate change. Air pollution results from the combination of high emissions and unfavourable weather (Jacob et al, 2009). So during the era of rapid changes of climate it is necessary to understand the impacts of climate change on air quality for the purposes of decision making regarding air quality management. In this discussion it will be tried to draw out the pictures of interrelated impacts of climate change on air quality. From the different literature reviews the discussion is carried out. The main aim is to find out that how different pollutant's creation process is stimulated due to the impact of climate change.

In a very general concept according the EPA, Sweden that the air pollution is affected in number of ways by the metrological system. They are:

➔Natural emissions of bio-genic volatile organic compounds (VOC) are emitted more readily in warm and sunny conditions;

➔Sea salt and soil dust particle emissions occur more effectively in windy conditions;

➔Photochemical reactions are dependent on available solar radiation**,** which is dependent on cloudiness;

➔In the planetary boundary layer, the part of the atmosphere closest to the ground, turbulence acts to dilute pollutants;

➔ Many chemical reactions and physical phase-transformations are dependent on temperature;

➔Wet deposition, i.e. scavenging of compounds with rainfall, is dependent on amount and intensity of precipitation;

➔ Dry deposition**,** i.e. compounds removed from the atmosphere by attaching to terrestrial surfaces, depends on meteorology in many ways. One important factor is vertical transport through the atmospheric boundary layer, which means that it is dependent on turbulence in the boundary layer

By influencing the meteorological process climate change can interact strongly with air pollution. Due to this effect of climate change on air pollution the emission standards that leading to acceptable levels of air pollution in one year can cause severe air pollution episodes in another. The impact nature of meteorological variation on air pollutants is given in the following table. The table is derived from the Jacob, 2009.

Table 3.3: Impact Magnitudes of Climatic Variables on Air Pollutants

Variable	Ozone	PM
Temperature	++	-
Regional Stagnation	++	--
Wind Speed	-	-
Mixing Depth	=	--
Humidity	=	+
Cloud Cover	-	-
Precipation	=	--

Source: Jacob,Darrell . Winner, 2009

Results are summarized as consistently positive (++), generally positive (+), weak or variable (=), generally negative (-), and consistently negative (--).

The sum up of the discussion can be written as the sensitivity of ozone to climate change is particularly high in urban areas, reflecting the high potential for ozone formation. This is not true for the background ozone (the ozone that is formed naturally in normal condition). Background ozone is not correlated with temperature, and is expected instead to decrease in the future climate as a result of increasing water vapour (Jacob et al, 2009).

On the other hand the response of PM to climate change is more complicated than that for ozone because of the diversity of PM components, compensating effects, and general uncertainty of applied model’s (In this case the Model is GCM=Global Circulation Model) projections of the future hydrological cycle. Observations show little useful correlation of PM with climate variables to guide inferences of the effect of climate change. Rising temperature is expected to have a mild negative effect on PM due to volatilization of semi-volatile components (nitrate, organic), partly compensated by increasing sulfate production. Increasing stagnation should cause PM to increase. Precipitation frequency, which largely determines PM loss, is expected to increase globally but to decrease in Southern North America and Southern Europe. PM is highly sensitive to mixing depths but there is no consensus among models on how these will respond to climate change.

3.6 Summary

In urban planning and policy tools the application of these uncertainties and probable casual relation should be considered. The establishment of this causal relationship and concerning policy application will help to make cost-effective decision to apply climate change policy in urban planning scheme with relation to the air pollution. From the discussion it is clear that the air pollution can influence the climate change situation by aggravating and reducing the influenced effects. There is very small evidence that air pollution can change the emission of GHG. So in integrated situation the concern is about to cope and to minimize the integrated effect. In this case (integrated level) the policy and tools should be **focus to the effects** instead to the emission standards of the air and GHGs.

On the other hand the question of air pollution is local. In a contextual situation it is a regional as well as a global problem. Especially the influence of climate change situation creates effects on the emission situation of Air Pollutants. In some cases it becomes as a fact to reduce the emissions and in some cases it acts in opposite direction. So in this case the first focus goes to the **emission situation and standards** and the policy and planning tools have to deal with the emission control policy and strategy.

In the following schematic diagram presents the influence scenario of Air Pollution and Climate change. The interacted relationship is presented in the same diagram.

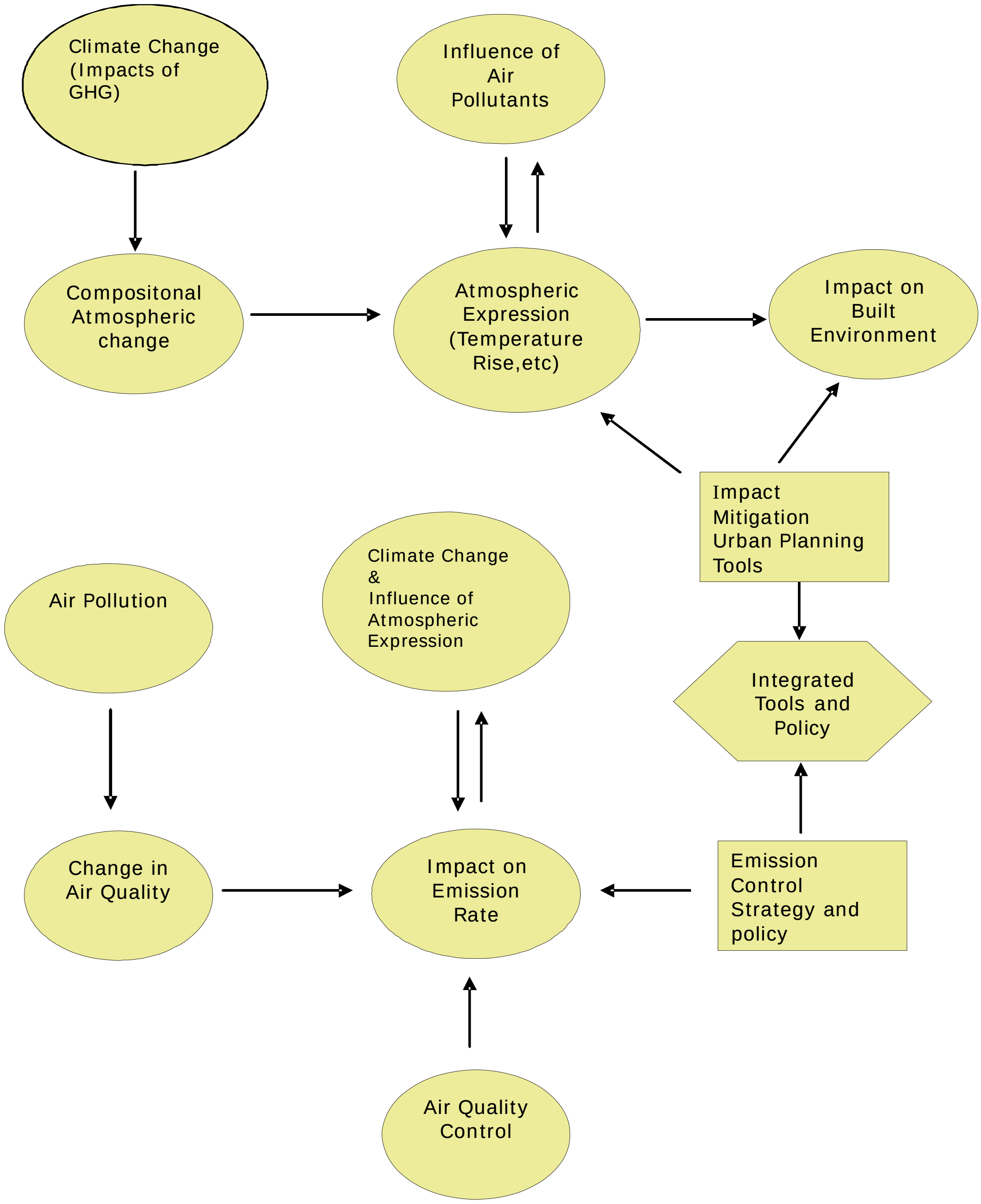


Fig3.1: Integrated Influence Scenario of Climate change and Air Pollution (Source: Author Derived by doing the analysis of different Studies)

References

1. Burtraw and Toman (1997), The benefits of Reduced air pollutants in the U.S from greenhouse Gas mitigation Policies, discussion paper, Resources for the Future.

2. Bytnerowicz Andrzej, Kenji Omasa, Elena Paoletti (2007), Integrated effects of air pollution and climate change on forests: A northern hemisphere perspective, *Environmental Pollution 147 (438-445)*

3. DOE: Department of Ecology, State of Washington (2010), What is climate change, Retrieved from the official website on July, 2010
http://www.ecy.wa.gov/climatechange/whatis.htm

4. EC: Environment Canada (2010), *Clean Air, Climate Change and Stratospheric Ozone Depletion* Retrieved on September, 2010 from the website of Environment Canada: http://www.ec.gc.ca/air/default.asp?lang=En&xml=C6DCEC3F-EA13-4DE9-B735-6F62328B8BB1

5. EPA Environmental protection agency, USA (2010), *Recent Climate change*, Retrieved on September, 2010 from
http://www.epa.gov/climatechange/science/recenttc.html

6. EPA,Sweden (2009) *Climate Change and Air Pollution-Two Sides of the same Coin* Editor: Håkan Pleijel, The Swedish EPA financed Book, ISBN 978-91-620-1278-6

7. IIASA: International Institute for Applied System Analysis (2004), The Regional Air Pollution Information and Simulation (RAINS) Model. Retrieved on July,2010 from: *www.iiasa.ac.at/rains/review/review-approach.pdf*

8. IPCC: Inter Governmental Panel on Climate change (1990) Potential Impacts on Climate Change" Report from working group II to IPCC Retrieved on September form: http://www.ciesin.org/docs/001-011/001-011.html

9. IPCC (2007): The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning (eds.)].

10. Jacob Daniel J, Darrell A. Winner b (2009), Effects of Climate change on Air Quality, *Journal of Atmospheric Environment,* No 43 (51-63)

11. Jirak Israel L. and William R. Cotton (2006), Effect of Air Pollution on Precipitation along the Front Range of the Rocky Mountains, *Journal of Applied Meteorology and Climatolog*y 2006; 45: 236-245

12. NOAA: National Oceanic and Atmospheric administration (2008), State of the Climate Global Analysis Annual. Retrieved on September,2010 from: http://www.ncdc.noaa.gov/sotc/index.php?report=global&year=2008&month=ann

13. Raes Frank (2006) "Climate Change and Air Pollution- Research and Policy" Global Change News Letter No.65 March 2006.

14. Ramanathan V, Feng Y. (2009), Air pollution, Greenhouse Gases and Climate Change: Global and regional perspectives, *Journal of Atmospheric Environment*, No 43 (37-50)

15. Ronald G. Prinn, John Reilly, Marcus Sarofim, Chien Wang and Benjamin Felzer (2005), Effects of Air Pollution Control on Climate, MIT Joint programme on Science and Policy of Global Change. Repot No:118

16. Srivastava (2009), *Environmental Pollution* APH Publishing, ISBN: 8131304787, 9788131304785 Retrieved from : *http://books.google.com/books?id=3Tn087o8JoUC&pg=PA5&dq=definition+of+air+pollution&hl=en&ei=yijwTPe9AYbrOf-bvboK&sa=X&oi=book_result&ct=result&resnum=1&ved=0CCoQ6AEwAA#v=onepage&q=definition%20of%20air%20pollution&f=false*

17. Swart R, Amann M,Raers F and Tuinstra W (2004), A good climate for clean air: linkage between climate change and air pollutants, *Climatic change* 66, 263-269

18. UNECE: United Nations Economic Cooperation for Europe (2010), *Air Pollution and climate change tackling both problems in tandem* Retrieved on September,2010 from : http://www.unece.org/press/pr2003/03env_p02e.htm

Chapter-IV

Comparative Scenarios Development of Planning and Policy Tools Against Climate Change and Air Pollution

Chapter IV
Comparative Scenarios Development of Planning and Policy Tools against Climate Change and Air Pollution

Key Word: Indirect Emission Control, Direct Emission Control, Emission level, Impact level, Urban Density, Urban Form, VMT, Green House Gas (GHGs), Transit Oriented Development (TOD), Travel Demand Management (TDM), Floor Area Ratio (FAR), Emission Density Zoning (EDZ), Urban Heat Island (UHI)

The problems of climate change and air pollution at city level are interacting in different dimensions. The happening of climate change and air pollution at city level has its own characteristics. Over the previous discussion it was shown how climate change and air pollution are interacting and influencing one another in the case of their taken place. In this chapter the discussion will be focused to the urban planning and policy tools that can be applied against climate change and air pollution simultaneously. It is concluded in previous chapter that there are two dimensions of the problem of climate change and air pollution. These two dimensions of the problems should be considered to mitigate and adapt the problem of climate change and air pollution at city level. One dimension is the **Emission level** and another one is the **Impact or Effect Level** of climate change and air pollution at city level. So in the search of framing the urban planning and policy tools the discussion will be elaborated under the two dimensions which are Emission control or Standard Maintaining policy and Effect or Impact adaptation policy. First of all the chapter will be discussed on the relational field of urban planning and policy that is matter of consideration in relation with the two dimensions of climate change and air pollution. At the later stage a comparative scenario will be developed to find out the inter linkages among those planning and policy tools. Figure 4.1 shows the interaction of the two dimensions of climate change and air pollution control dynamics with respective planning and policy tools.

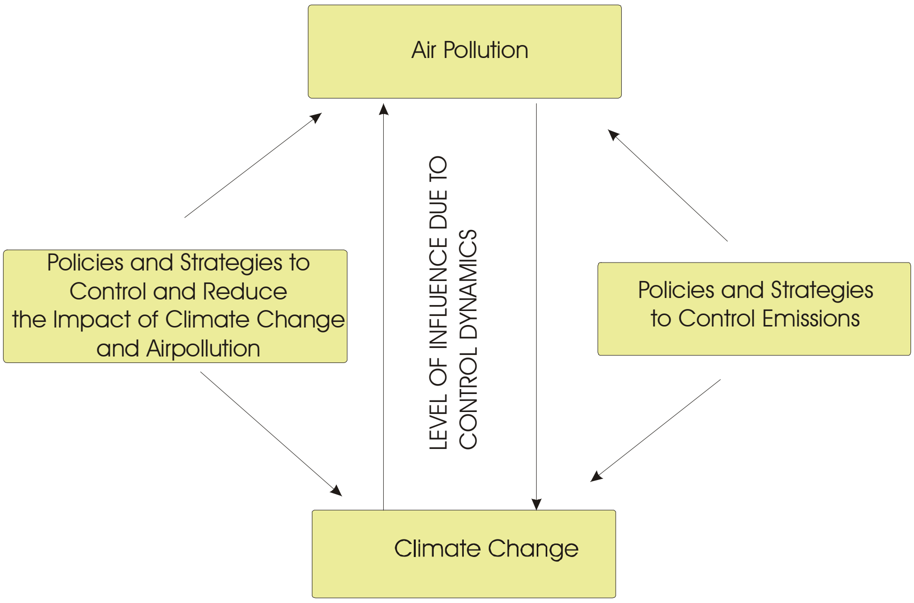


Figure 4.1: Emission and Impact Control Dimension and Influence Interaction
Source: Author Derived

In the next section the planning and policy tools will be discussed under these two dimensions of the problems of climate change and air pollution. In the following table the topics of the next discussions are outlined here to give a prior framework of the discussion.

Table 4.1: Urban Planning and Policy Tools Discussion Framework

4.1 Emission Control Based Planning and Policy Tools	Category of Planning and Policy Tools	Planning and Policy Tools
	4.1.1 Indirect Emission Control	4.1.1.1 Land Use Strategy
		a. Increasing and Maintaining Density
		b. Urban Spatial Form
		c. Floor Area Ratio
		d. Zoning
		e. Urban Design Aspects
		f. Transit Oriented Development
		4.1.1.2 Travel Demand Management
		4.1.1.3 Urban Livelihood Improvement Strategy
	4.1.2 Direct Emission Control	4.1.2.1 Mitigation fee
		4.1.2.2 Emission Density Zoning
4.2 Effect Based Planning and Policy Tools	4.2.1Urban Heat Island Adaptation	4.2.1.1 Reduction of Anthropogenic Heat
		4.2.1.2 Improvement of Artificial Surface Covers
		4.2.1.3 Improvement of Urban Structures.

4.1 Emission Control Based Urban Planning and Policy Tools

It is evidenced that in the interaction level, air pollutants are affected by the conditional situation of climate change. So in the identification of emission control strategies the focus will be given to those planning tools that are effective to control the climate change impact as well as the control the emission at city level. Emission control of different pollutants and GHGs from different sources is a way to mitigate the air pollution and climate change. Mitigation action generally falls into **two categories**: Altering the supply source of energy and reducing the demand for energy (Condon et al, 2009). Urban planning and policy tools can be an effective way to control the emission by reducing the demand of the energy. Most of the urban planning tools are discussed in different literatures to control the emission in different levels. The emission control urban planning and policy tools are divided in two categories: **Indirect Emission Control** Urban Planning tools and Policy and **Direct Emission control** Urban planning and Policy tools.

4.1.1 Indirect Emission Control Urban Planning and Policy Tools

The urban planning tools that control the air pollutants and GHG emissions are influenced by the level of scale at which it is going to be implemented. The urban planning and policy tools differ based on the scale of application. According the Condon et al (2009) GHG emissions are influenced by decisions made at all scales-from individual projects at the site scale to infrastructure projects at the regional scale. For example community or master plans at the municipality scale might include increased density targets that could potentially impact rider ship on regional and local transit, increase the viability. In the following the discussion will be carried out to find out some urban planning tools that indirectly influence the air pollution and GHG emissions at different scales.

4.1.1.1 Land Use Planning and Emission Control

Land Use planning is a strong urban planning tool to control the different aspects of different urban systems. The juxtaposition of land use planning with different urban systems (i.e. transportation system, environmental system) takes place very closely. The alteration of land use and its effects on the living and working environment and transportation pattern must be considered as well (Babcock et al, 1975). In some cases they are directly related and in some cases inversely related. In the strategic and urban planning level the integration of land use strategy with air pollution and climate change issue can be an effective way to address those problems simultaneously. The integration of air pollution control into the long-range land use planning process of a region involves the determination of the most effective combinations of emission control legislation, zoning ordinances, highway routing, stack emission control devices, etc. to prevent the creation of source clusters as the region grows, and to insure patterns of residential, commercial, and industrial development and transportation networks consistent with the maintenance of air quality standards (Dajani et al,1977). The use of an integrated land use planning approach to air pollution control has many desirable features. These desirable attributes include the insurance of long-term maintenance of air quality standards, the tailoring of the emission-control regulations to the character and projected growth of the region, the ability to evaluate revised growth patterns, and the development of fair and unequivocal regulations (Dajani et al, 1977). To conceptualise those desirable features and to point out the influence of each features, understanding of the interactions among different components in relation with land use and air pollution are important. Babcock (1975) has shown such diagram in a very simple way where the interactions among sources, meteorology, spatial pattern and receptors are shown.

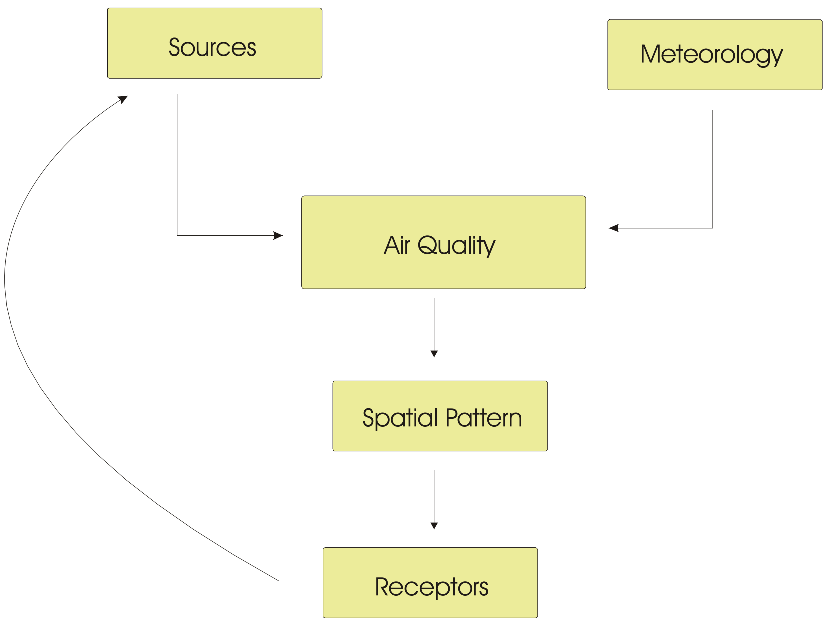


Figure 4.2: Land Use and Air Pollution Interaction (source: Babcock, 1975)

In a given location the air quality is affected by the sources and meteorology. Besides, spatial pattern and source receptor geometry is also an important factor to the issue of air quality as they influence one another. So land use consideration should be an important part in air pollution and air quality management. There are more subtle influences related to land use. Spatial pattern affects the amount of pollution emitted. Cities usually develop for some certain reasons and relationship between people, air pollution and land use are complex that usually exists. Land use options and selection will directly affect the amounts of air pollution produced and then the land use patterns in combination with the meteorology will directly affect the air quality experienced by receptors. Land use is like a two-edge sword: it has an effect on the amounts of pollution produced, as well as on the severity of pollution received (Babcock et al, 1975). The phenomenon is also true for GHGs emission and in case of the issue of climate change. In this context the urban planning and policy tools concerning the land use planning strategies should deal with the object of identifying the amount of pollution produced from a specific land use and its originated severity from that specific land use. In the following different tools of land use planning and strategies concerning the emission control of pollutants and GHGs are discussed.

a. Increasing and Maintaining Density

Urban density is a term that is used as a measure in urban planning to address various challenges that cities are facing such as traffic congestion, increased pollution, excessive energy consumption and urban sprawl. In the field of urban and environmental planning the density can be addressed as good density and bad density. Up to a certain level the intensification of density is a good tool to control the emissions. The resultant of the density intensification is not the direct effect of reducing or controlling the emission of GHGs and air pollutants. Reducing GHGs and air pollutants through the application of intensification of urban density results from the indirect controlling of source activities. In a sense the reduced level of GHGs and air pollutants for the densification of urban area results from the shifting of the GHGs emission related activities (Dodman, 2009). The process of this benefit of reducing emission is explained in another way that is scale of economics. The high concentration of people and economic activities in urban areas can lead to economics of scale, proximity and agglomeration that can have positive impact on energy use and associated emissions; whilst the proximity of homes and business can encourage walking, cycling, and the use of mass transport in place of private motor vehicles (Satterthwaite, 1999) The benefits of higher urban densities are considered as mixed and context oriented. Urban compaction and density intensification may be positive only up to a certain level (Dodman, 2009). Here this urban densification tool for reducing GHGs emission and air pollution will be discussed from its domain of influence in respective field. The influential domain of urban density concerning the GHG emission and Air pollution are shown the following table:

Table 4.2 Influence Domain of Urban Density Concerning GHG Emission and Air Pollution (Source: Author Derived, 2010)

Domain of Influence (+)	**Process of Influence**	**Linkage to GHG and Air pollution**
Transportation	-High and compact urban density helps to reduced VMT (Vehicles Miles travelled) -Favourable physical condition to public transport market share and public transport service intensity.	-Acts as a way to reduce the demand of energy. -reduced demand means reduced level of burning of fossil fuel and also reduced level of emissions.
Building energy consumption	Constraints on the size of the residential dwellings imposed by the scarcity and high cost of land.	-Small dwelling units reflect the less energy consumption and less emissions.
Domain of Influence (-)	**Process of Influence**	**Linkage to GHG and Air Pollution**
Localized climatic Effects (Increased temperature)	-Caused increased localised temperature	Deteriorate the air quality by influencing the percentage of PM
Increased Traffic Volume	-In intensified urban area traffic volume become high in a certain time period that cases traffic congestion	-Traffic congestion and slower movement of the traffic causes more emission and pollution.
Risk of Vulnerability	-High urban density expose huge number of people to the respective effects climate change and air pollution.	- Little expose of climate change and air pollution but there is chance of great risk of havocs.

a.1Transportation

Intensified Urban density has positive effects on the environment as a consequence of the reducing of energy demand in transportation sector. Compactness or intensified urban density is one of the factors of sustainable urban system. Whilst Neuman (2005) concludes that compactness alone is neither a necessary nor sufficient condition for sustainability. Jabareen (2006) identifies seven design concepts of sustainable urban form-compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greening. He used these concepts to compose sustainable urban form matrix. The compact urban form or intensified urban density is also a strategic tool of sustainable urban development and operations of different urban systems. In the transportation sector the compact urban form or intensified urban density works in different ways to reduce the demand of energy and fuel consumption. Intensified urban density (Up to certain level) and compact city form affects motorized trips for two reasons. First for a given population, the higher the density, the shorter the distance between two points in general and the higher the number of people who can walk to work or shopping (Bertuad, 2002) According to Bertuad a person by walking up to 12 minutes can easily reach any point in an area of 100 hectares (ha). As a consequence, a job or a shop located in an area with density of 10 people per ha (typical density of US suburb) can be reached by 1,000 people without requiring motorized trips, but 30,000 people can reach the same job within the same walking time if the density is 300 per ha (typical density in Asian City Central Business districts)

Second, the higher the density the easier is to provide frequent and easily accessible public transport services. Thereby higher density is reducing the demand for private motorized transport. So it is clear that in transportation sector the urban density is working as an indirect way to shifting the dimension of emission of GHG and air pollutant by decreasing the urban movement boundary and by increasing size of the maximum movement option that is public transport. Decreasing the movement boundary indicates the reducing the vehicles Miles Travelled (VMT) or Vehicles Hourly Travelled (VHT). The logic is straight forward. The VMT and VHT create vehicle emissions; higher VMT and VHT are associated with single use, low density development especially when development is located outside the urban core.

There is one to one relation between the reduced VMT and CO_2 emission. A 30% reduction in VMT will result in a 30% reduction in CO_2 emissions (Ewing, 2007). For example here a comparative information on urban density and respective comparative information on public transport share and public transport service intensity are presented here. Figures 4.3, 4.4 and 4.5 are representing the mentioned information that depicts the relation among the intensified urban density. From the figures it is clear that the countries with high urban density also giving high intensity public transport service and holding the greater share of public transport market.

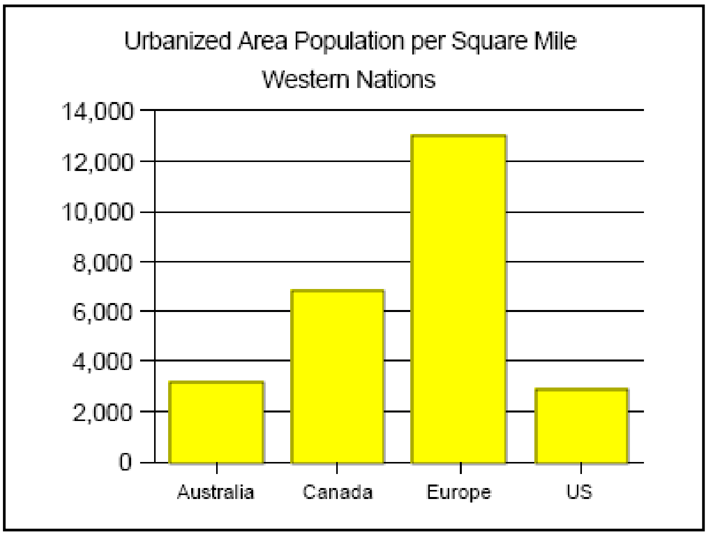


Figure 4.3 (Source: Wendell Cox, 2000)

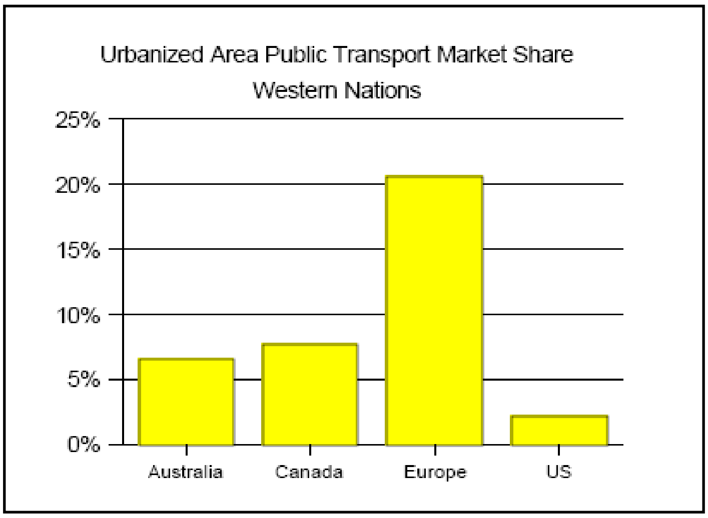


Figure 4.4 (Source: Wendell Cox, 2000)

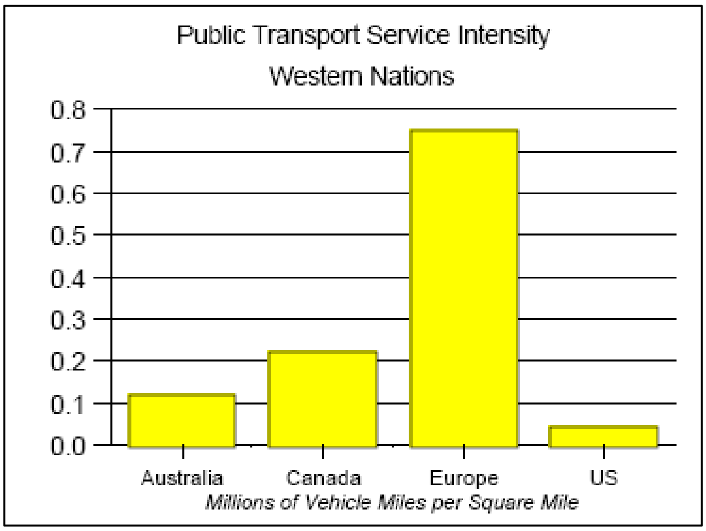


Figure 4.5(Source: Wendell Cox, 2000)

The reason behind this higher market share of public transport is the favourable condition due to the dense urban settlements. The existence of dense urban settlements helps to operate the public transport within minimal cost. Moreover, the densification of services makes it easier to operate the public transport services within an effective time frame. On the contrary in case of low density the provision of public transport becomes expensive moreover the service is not in a level due to the long and ineffective distances among the different services. Some researchers suggest that each doubling of average neighbourhood density is associated with a decrease in **per-household vehicle use** of 20-40 percent, with a corresponding decline in emissions (Gottdiener and Budd 2005). In the table 4.3 the relation among gasoline use and population density, job density and transit passenger are given. It is evidenced the correlation of gasoline use with population density, job density and passenger transit is negative and highly correlated. It means that the relation is inversely correlated.

Table 4.3 Gasoline Use and Relation among Population Density, Job Density and Transit Passengers

City	Population Density Persons per acre (1980)	Job Density Jobs per acre (1980)	Transit Passengers (1980)	Gasoline Use Gallons Per Capita (1980)	Correlation
US Cities	5.7	2.8	324	446	Density and gasoline use: -.82
Australian Cities	5.7	2.4	532	227	Transit Passenger and Gasoline use: -.81
Toronto	16.2	8.1	1227	265	Job Density and Gasoline use: -.79
European Cities	21.9	12.6	1112	101	
Asian Cities	64.8	28.8	1900	42	
Moscow	56.2	----	>2647	3	

Source: Derived and calculated from Newman and Kenworthy, 1989

In the figure 4.6 the relation of urban density and gasoline use are shown with respect with different cities around the world.

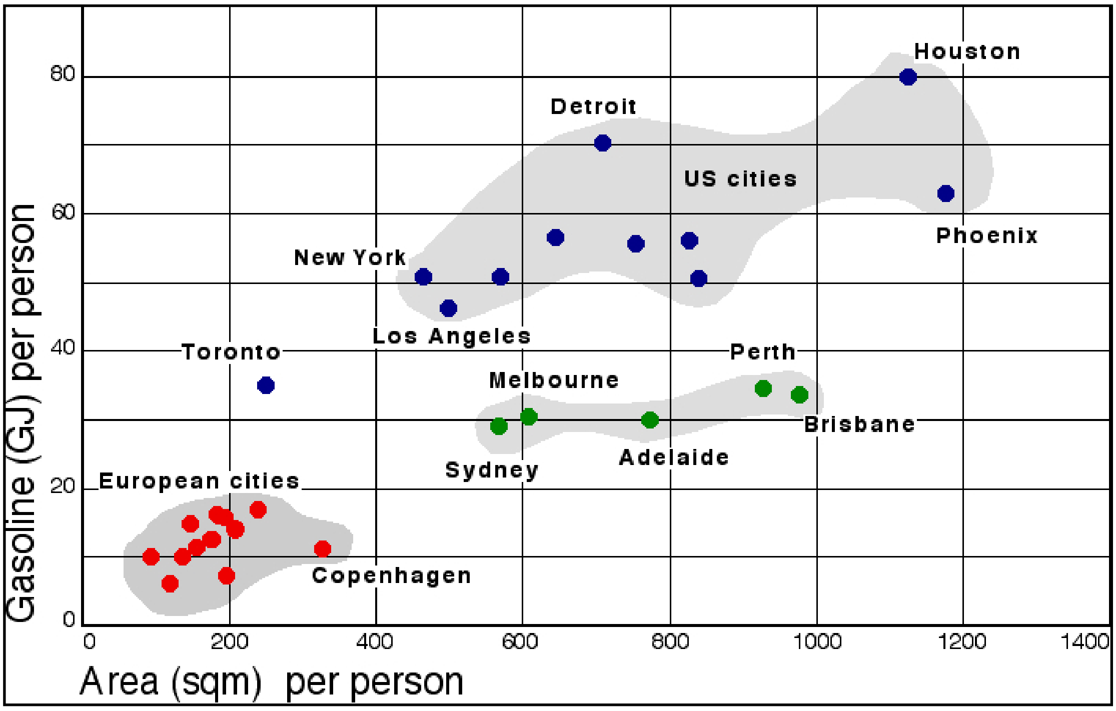


Figure 4.6: Relationship between Urban Density and Gasoline Use.
Source: wikipedia.org, Newman and kenworthy, 1989

In a generalized way it is said that increasing and managing the urban density is a way to reduce the demand of energy consumption in transport sector that causes less emission of GHGs and Air Pollutants.

a.2 Energy Consumption of Buildings

The urban density has implication on the building energy consumption. Any kind of imposed urban or guided urban density policy will give causes to the small dwelling units. On the other hand the high land value gives adverse situation to grow up horizontally. As a result there is a chance to utilize the land with its maximum effectiveness. Development concentration in some cases can have environmental advantages, for example through the sharing resources. Most obviously, more intense use of land and sharing infrastructure-energy and water supply, drainage, roads, building and public transport-reduces the energy per capita associated with its construction (and possibly maintenance) and benefits from an economy of scale by comparison to a more dispersed urban configuration (Steamers,2002). Less energy consumption in terms of electricity demands less production what also help to reduce the emission as well as pollution at city level. This phenomenon of reduced energy consumption is totally context oriented. In different context this scenario will be totally different. This happens due to the variation of socio-economic condition and climatic condition. In tropical countries the high urban density can increase demand of energy where as in winter prolonged countries this can be reverse. Moreover the types of building also play an important role in conjunction with this phenomenon. The issues are addressed here to consider the domain of influence of urban density but the scope of detail discussion is out of scope considering the direct relation with air pollution and GHG emission.

a.3 Localised climatic effects

High urban density has strong influence on micro climatic condition in local scale. In the discussion of the climate change and air pollution interaction it is explored that the increased temperature stimulates the higher concentration of PM in the air at local as well as regional scale. So in this context there is two dimensional effect of increased temperature on air quality. Due to climate change the increased temperature is matter of concern in global scale. The resultant sometimes also comes in local level. In addition of this the applicable tool urban density as a way to mitigate and control the emission and can deteriorate the air quality by increasing micro climate. A move toward a more compact city with built up activity centres would result in a larger heat storage fraction because of changes in surface characteristics through reduced albedo and reduced vegetative cover but more so through increased built up surface area (Coutts et al,2006). In such a networked effect there have to apply different tools to mitigate and control the integrated effects. The tools will be explored in the discussion of the effect based urban planning and policy tools.

a.4 Increased traffic volume and average vehicle speed

Dense urban area with its compact service and large share of public transit can't be able to clear the image of the road with full of traffic. This is due to the provision of huge movement within limited space. Traffic volumes per square mile in Europe are approximately 50 percent higher while Canadian volumes are nearly 20 percent higher than USA. In case of Asia the figure is 80% (Wendell, 2000). Figure 4.7

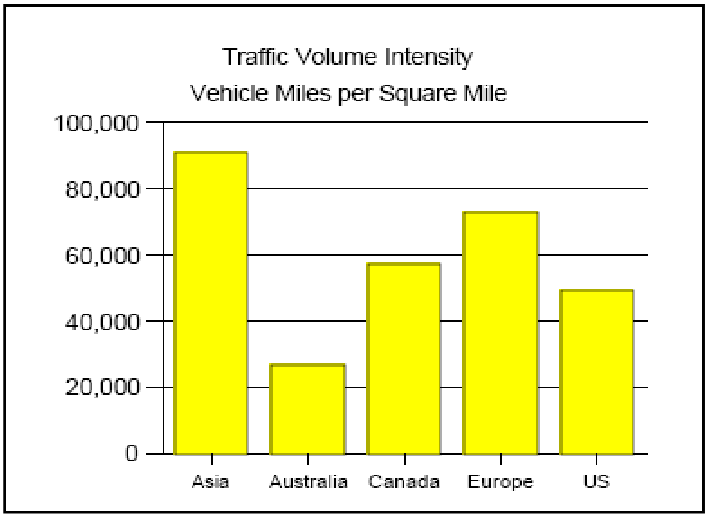


Figure 4.7(Source: Wendell Cox, 2000)

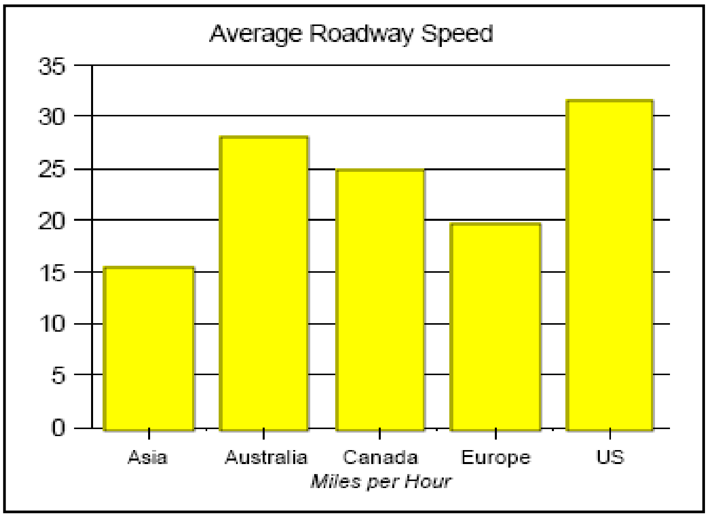


Figure 4.8(Source: Wendell Cox, 2000)

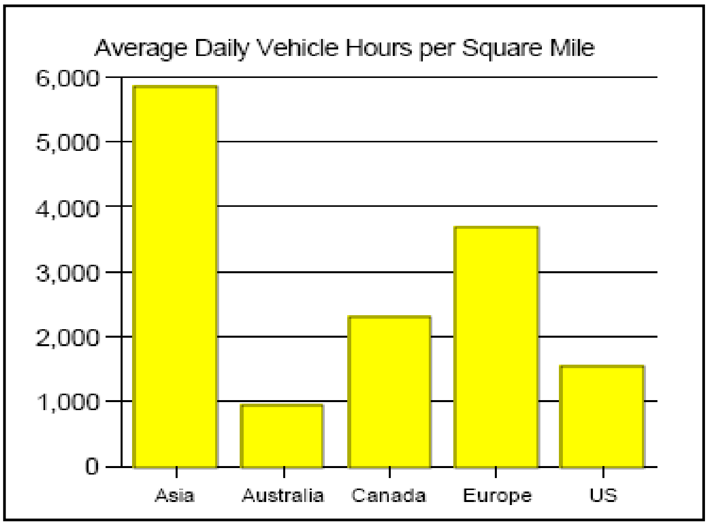


Figure 4.9(Source: Wendell Cox, 2000)

As a result traffic speeds become slower where densities are higher. In the United States, average roadway speeds in urban areas are nearly 32 miles per hour. European speeds are less than 20 miles per hour, while Canadian speeds are less than 25 miles per hour. The highly dense Asian urban areas have speeds less than 16 miles per hour (Figure 4.8). As a result, the hours of motor vehicle operation per square mile are much greater in Europe, Canada and Australia (Figure 4.9). Given the fact that air pollution rises as urban automobile speeds decline and as “stop and start” operation increases, this adds to air pollution (Wendell, 2009). So maintain and increasing urban density solely can’t bring any good result in respect of controlling emissions. In the one hand urban density promote the less energy consumption but on the other hand poor physical environment promote emissions. So in a sense it will be a balance way. In the application of this policy the balance inter transaction of cost and benefit should be dealt with high care to get the optimum result.

a.5 Factors that Affect the Urban Density and Relationship with Emission

In the above discussion it is explored that the intensified urban density helps to reduce the emission indirectly. Some researchers considered it as a way to ensure sustainable urban form with other design concept. The issue of intensification of urban density incorporates number of dimensions. Consideration of different dimension in case of density intensification is necessary and effective to get the optimum result to mitigate and control emission. Based on the different dimensions urban densification can be measured in the following broad titles:

➔Urban Demographic Density (UDD): is a measure of population concentration in an area (usually people/households but can include other species). There are two commonly used measures of urban population density. In this concept the job densification should be considered. An urban area with densely populated but with less job densification can’t meet the condition for controlling or reducing the energy consumption in transport sector. People of dense area have to move to other places for job purposes. As a result an area with dense population apparently can’t be able to reduce the energy consumption as well as emission of transport sector.

➔Urban Land Use Density (ULD): With UDD and job density an urban area may not be able to reduce the energy consumption in transport sector. This usually happen due to the less ULD. If the area dominated by certain type of land use and if there is no diversity of land use intensity the object of reducing the energy emission and controlling the emission will not be a successful one.

➔ Urban resource Density (URD): This is another dimension of urban density. This is a measurement of resource concentration. Especially demand for consumption and waste are generated spatially by land use activities. The city with production based economy concentrate more resources than a city with service based economy. In this context it can be said that city with high productive based economy dominates the concentration of resources that means high URD. The city with high URD produces more emissions. The example of Barcelona can give a clear idea that how URD works to produce more emissions. In the following table the statistics of CO_2 emission of the year 1996 are presented. It is clear that the CO_2 emission share of Barcelona is less than its country's average emission. This is not only because of the compact urban form and high density. It is also the result of the less URD as city has service base economy.

Table 4.4: CO_2 emission Statistics (2004) of the City of Barcelona

Name of the city	Country's Average CO_2Emission	City's Average Emission	Causes
Barcelona	10.34 tons/capita (2004)	3.4 tons/capita (1996*)	-Service based economy -90%electricity produced by nuclear or hydro energy. -city's Mid climate condition -compact urban structure.

Source: (Baldasano *et al* 1999). *Data for 2004 was not available.

➔ Socio Economic Dimension: this is another important dimension in case of studying the urban density and the relation of emissions. The income level of the people in a certain area is important variable in case of assessing the GHG emissions along with urban density. There is complicated series of interactions between urban density, economic status and greenhouse gas emissions. The residents of the densely populated cities of low- and middle income countries are generally wealthier than residents of their hinterlands, yet far less wealthy than residents of the (less densely populated) cities in high-income countries. This confounds a straightforward relationship between urban density and greenhouse gas emissions: in low income countries, residents of denser settlements are likely to have higher per capita emissions as a function of their greater wealth than residents of surrounding areas; in high-income countries, residents of denser settlements are likely to have lower per capita emissions than residents of surrounding areas as a result of smaller housing units and greater use of public transportation systems

(Dodman,2009).For example, cities in South Asia are not only more densely settled than cities in North America, but also have much lower greenhouse gas emissions: the difference in the latter is due much more to income and consumption patterns than to variations in the former. Glaeser and Kahn (2008) conclude, “holding population and income constant with the spatial distribution of the population are also important determinants of greenhouse gas production”. So in case of applying the tools of urban densification strategy as a way to control and mitigate the emissions of GHG as well as air pollutants there have to consider the socio economic condition of the certain city and have to fix up the certain level of the densification.

b. Urban Spatial Form

Urban spatial form and its overall structural shape have influence in relation with air quality of a certain area. There are number of basic shapes of the urban area that are matter of discussion in relation with the quality of the air. How these basic shapes of the city are influencing the air quality and what are the other factors that are related with the issue of developing the particular urban form and structure will be the major focus of discussion. The influence of urban form on environment is still poorly understood (EEA, 2000). The urban spatial structures have also influence the performance of different urban systems. From the work of Bertuad (2004) it is evidenced that there are some clear linkages among the city shape and transit, motorization and air pollution due to transport use. Here it will be tried to go in depth analysis of how city shape is influencing the air quality and what are the ways to come out from this. Along with this, it is also matter of concern that the city is composed of number of systems. Each of the system has directly and indirectly some short of influence on the other systems. It is not possible to say that the influence of spatial structure is not limited and concentrated to one system. Instead it can be said that on some systems the influence of spatial structure are more dominant in character than the others. It is also not possible to give the optimum spatial structure of the city due to changing development objective of the city over time. City development objectives change over time, so defining an optimum city shape is impossible (Bertuad, 2004). Spatial structures are shaped by market forces interacting with regulations, primary infrastructure investment and taxation. Shaping the city becomes a matter of question of when it as considered as part of different systems, there is no optimal city shape. City shape can be improved only in relation with priority objectives of a certain where spatial structure and city shape should be focused with specific objectives. With specific objective it is possible to optimise the situation. In case of air quality and emission the fact of spatial organization and city shape can be analysed from a very rough hypothesis. The hypothesis is that the spatial structure of an urban area usually helps to reduce the demand of mobility and reduced demand of mobility results less emission and better air quality of urban area. Figure 4.10 shows this hypothetical relation.

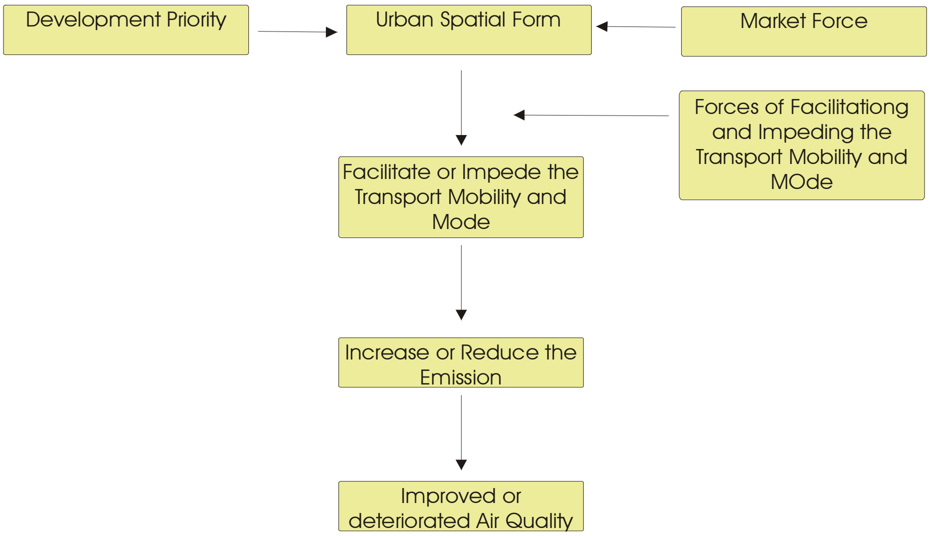


Figure 4.10: Hypothetical Influence Process of Spatial Form on Emission (Source:Author Derived)

In the following different urban shapes and spatial structures are discussed from the point of view of above hypothesis.

b.1 Monocentric City

To consider the air quality and emission condition of a city from the spatial structure and shape perspective it is necessary to frame out that how they influence the nature of the different trips. Monocentric city is most widely used spatial structure and urban form to analyse the spatial organization of the cities. In urban economics this form is widely used to clarify the different issues related with land rent and land use distribution. The works of Alonso (1964) and Muth (1969) on density gradients in metropolitan areas are based on the hypothesis of a monocentric city. So the existence of monocentric city in urban form is very basic. It has become obvious over the years that the structure of many cities has departed from the monocentric model and that many trip-generating activities are spread in clusters over a wide area outside the traditional Central Business District (CBD) (Bertuad et al, 2001).

The trips generation pattern in monocentric city is very simple and environmental friendly. The reasons behind these happenings are very concrete. First reason, is the trips are very shorter in monocentric city. In a dominantly monocentric city, trips usually are shorter as the majority of trips are from the periphery to the CBD. In most dominantly monocentric cities, the population's center of gravity coincides with the CBD, as is the case in New York, London, Paris, Moscow, and Shanghai. The reason behind this shorter trip scenario originated from the unified labour market. Due to unified labor market it is very easy to facilitate the mobility along the radial road or rails from the periphery to centre **(figure a)**. This type of radial road network development is the best geometric way to reduce the length of trips. In this case, the larger the proportion of trips to the CBD, the shorter the trips will be since, by definition, the centre of gravity is the point from which the sum of distance weighted by population is the shortest. On the other hand due to shorter trips the land value becomes higher near to the CBD. This situation in a way generates higher density in the adjacent area of CBD. Due to this density becomes result of market. Densities, when market driven, tend to follow the price of land—hence, the negative slope of the density gradient from the centre to the periphery (Bertuad, 2001). Higher density is a positive force to manage the city development in favour of environment. Moreover it ensures the optimum utilization of land and reduces the consumption of energy in different urban systems especially in transportation system.

Second Reason**,** the monocentric city provides efficient structures to the city to provide public transit. This is also a very effective option to reduce the emission level and to improve the air quality. In case of public transport system it is very easier to operate an efficient public transport system when the destination of the majority of trips is concentrated within the central business district (CBD) area. As a consequences, in cities that are predominately "monocentric" (most jobs and retail concentrated in the CBD), the share of trips using public transport tends to be higher than in "polycentric" (no dominant center) cities where the CBD only a small fraction of the total number of jobs and retail shops (Bertuad, 2001).

b.2 Polycentric City with Urban Village Version

The polycentric city is also emerged from the concept of unified labour market. From this concept of idealized unified market there arouse the concept of polycentric city with urban village version. This is concept where it is planned to grow up a self sufficient communities around each cluster of employment. Some urban planner termed it as self-sufficient "urban villages" that are aggregated to form a large polycentric metropolis **(Figure b)**. In such a large city, trips would be very short; ideally, everybody could even walk or bicycle to work. According to the Bertuad (2004), no one has ever observed this phenomenon in any large city. A metropolis comprised of self-sufficient "urban villages" would contradict the only valid explanation for the existence and continuous growth of large metropolitan areas: the increasing returns obtained by larger integrated labor markets. The urban village concept is the ultimate labour market fragmentation. Although there are many polycentric cities in the world, there is no known example of an aggregation of small self-sufficient communities. Despite not being encountered in the real world, the utopian concept of a polycentric city as a cluster of urban villages persists in the minds of many planners. For instance, in some suburbs of Stockholm, urban regulations allow developers to build new dwelling units only to the extent that they can prove that there are a corresponding number of jobs in the neighborhood. The satellite towns built around Seoul and Shanghai are another example of the urban village conceit. Surveys show that most people living in the new satellite towns commute to work to the main city, while most jobs in the satellite towns are taken by people living in the main city. Due to this both way direction of movement pattern the number of tips generated are increased instead of decreased condition. This type of spatial arrangements is not good in terms of emission and improved air quality.

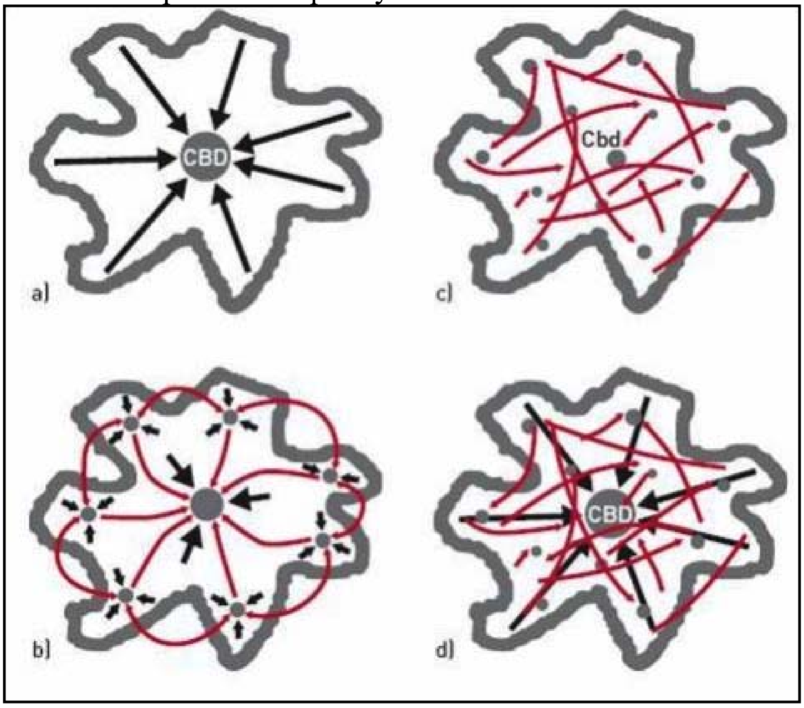


Figure: 4.11 Typology of Urban Movement According to Bertuad

a) *The monocentric Model*
b) *The polycentric model: The urban village version*
c) *The polycentric Model: The random movement version*
d) *The mono-polycentric model: Simultaneous radial and random movements*

Legend: Schematic representation of trip pattern within a metropolitan area according to Bertuad. Strong Links (Black Arrows) and Weak Links (Red arrows) Source: Bertuad,2001

b.3 Polycentric City

In reality, a polycentric city functions very much in the same way as a monocentric city: jobs, wherever they are, attract people from all over the city. The pattern of trips is different, however. In a polycentric city, each sub centre generates trips from all over the built-up area of the city **(Figure c)**. Trips tend to show a wide dispersion of origin and destination, appearing almost random. Trips in a polycentric city will tend to be longer than in a monocentric city, ceteris paribus (Bertuad, 2001). For a given point in the city, the shorter the sum of trips to all potential destinations, the higher the value of land should be. A geometrically central location will provide trips of a shorter length to all other locations in the city. Therefore, we should expect polycentric cities also to have a negatively sloped density gradient, not necessarily centered on the CBD but on the geometric center of gravity of the urbanized area. The slope of the gradient should be flatter, as the proximity to the centre of gravity confers an accessibility advantage that is not as large as in a monocentric city. The existence of a flatter but negatively sloped density gradient in polycentric cities can be observed in cities that are clearly polycentric, like Los Angeles or Atlanta.

Poly centric city is not suitable for the provision of public transit. In monocentric cities, most trips have multiple origins (the suburbs) but have one group of “clustered” destinations (the city center). In polycentric cities, most trips have multiple origins and multiple destinations. Consequently, in a dominantly polycentric city, there is a multiplicity of routes with few riders. As a result, transit systems can operate efficiently in monocentric cities but are difficult to operate in polycentric cities. This situation indicates the more energy consumption trend in polycentric city and in a way more emissions from transport sector.

b.4 Spatial form Driving Behaviour and Pollution

The amount of air pollution generated by urban transport depends on the length, speed and number of motorized trips and the type of vehicles. For a given urban population, the length and number of motorized daily trips are closely correlated with the average population density in built-up areas and the spatial distribution of trip destinations and origins. Therefore, low density, polycentric types of urbanization have a double effect on pollution generated by transport. First, it increases trip length compared to denser, more monocentric structures, and second, it increases the number of motorized trips as the proportion of transit trips and walking trips decrease with density. Second, the speed and acceleration can directly influence the rate of emission. Estimates of vehicle produced urban air pollution are based on traffic flow characteristics, vehicle numbers, vehicle types and total km of travel (USEPA, 1984). Exhaust emissions of NO_x (nitrogen oxides), HC (hydrocarbons) and CO (carbon monoxide) are dependent on traffic flow characteristics which are normally measured by a representative driving cycle for the whole metropolitan area (e.g. Simanaitis, 1977). Kent and Mudford (1979) found that the typical emissions under Australian urban driving conditions could be expressed as-

$$[CO]=465S^{-0.97}$$

$$[HC]= 21.5\ S^{-0.73}$$

$$[NO_X]= 2.2+.008S$$

Where [CO] is the carbon monoxide emission (g km- 1), [HC] the hydrocarbon emission (g km- 1), [NOx] oxides of nitrogen emission (g km- 1) and S the average vehicle speed (km h-1).

So the observed variation in average speed would reflect a variation in emission rate as a function of distance from CBD. The rate of emission is not only related with the speed, it is also related with the acceleration. For example, Kent and Mudford (1979) found that a three dimensional plot of emission rates against speed and acceleration led to parabolic surfaces for CO and HCs, while NOxs show a general increase in emission rates with speed and acceleration. In particular, they found that both CO and NOx show marked increases in emission rate with positive acceleration. This type of technical relation makes the relation with spatial variation that can facilitate or impede the speed and acceleration of the vehicle (Lyons et al, 1990). On the other hand speed and acceleration can also be influenced by the engine technology, city pattern and density. Engine technology and fuel types also play an important role in the amount of vehicular pollution and can counteract or attenuate the effect of unfavourable spatial structure. The comparison between Atlanta and Barcelona illustrates an interesting example of technology's impact on urban air pollution. In 1999, the average yearly level of nitrogen oxides was 47 $\mu g/m^3$ in Atlanta compared with 55 $\mu g/m^3$ in Barcelona. Air pollution caused by traffic is greater in Barcelona than in Atlanta, despite the fact that Barcelona's density is 28 times higher than Atlanta's (figure: 4.12), 30% of trips in Barcelona are by transit, and 10% are walking trips. This is due to laxer emission standards for vehicles—in particular, the use of diesel fuel for cars (about 55% of private cars use diesel in Barcelona). In addition, vehicles in Spain tend to be older than those in the US. For the same model, older cars may emit as much as ten times the amount of pollutant emitted by new cars; thus, in some cases, air pollution might be more sensitive to age and quality of vehicles than to urban spatial structure. Compared to low density polycentric structures, high density monocentric structures certainly tend to decrease the total amount of pollutant emitted by transport. However, the level of pollution exposure in dense monocentric city centers might be higher because of the more intense and slower traffic as emission rate is also the function of speed. Strict bans of on-street parking to increase the speed of traffic flows and general traffic management measures are necessary to decrease high pollution exposure in central city areas besides the issue of spatial structure and density.

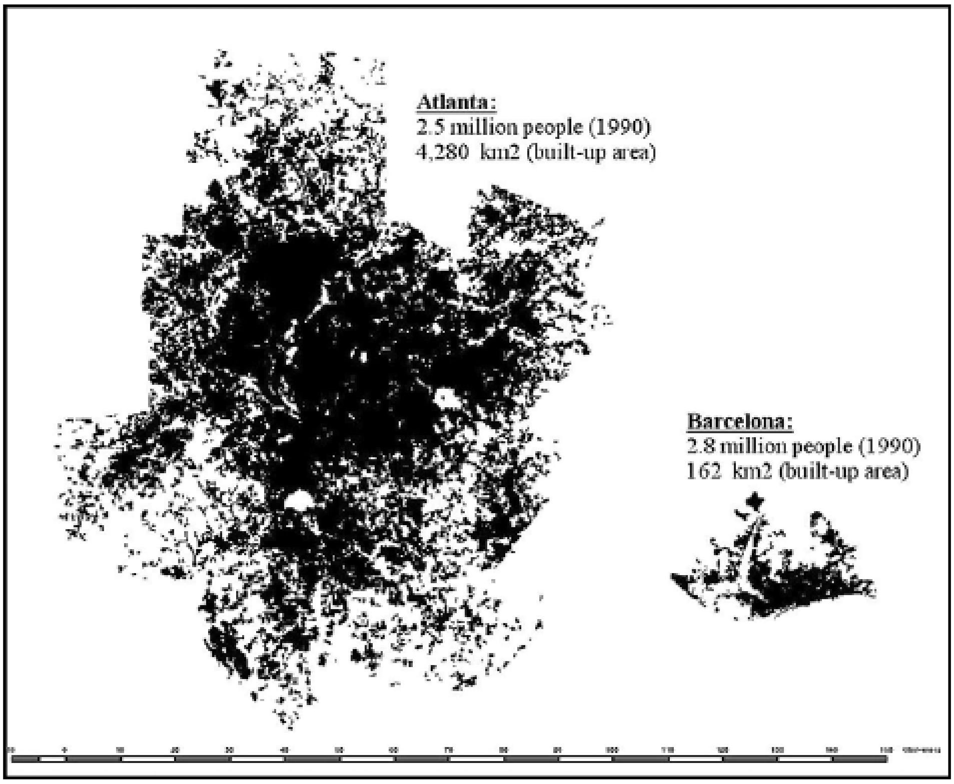


Figure 4.12: Built up Area of Atlanta and Bercelona at the Same Scale

The study conducted by Borrego et al (2006) is another example of the relation between the spatial structure and emission causes due to the influence on pattern of the urban traffic. In his study he studied three types of hypothetical city. The cities are (figure 4.13):

The Disperse City is characterized by low density, large area requirements and separation into distinct zones for residential, commercial or industrial uses, with the consequent high car use dependence. This city structure is known as urban sprawl (EPA, 2001).

The Corridor City is characterized by growth in linear corridors with origin in the city centre, supported by high quality transport infrastructure (highways). This is a ‘‘network city’’, conceived around axes and nodes, offering partly unmixed and partly mixed functions.

The Compact City uses less area than the Disperse City due to high density, with mixed land uses and complementary functions located close together (housing, shopping, offices), allowing the reduction of travel length and number of trips.

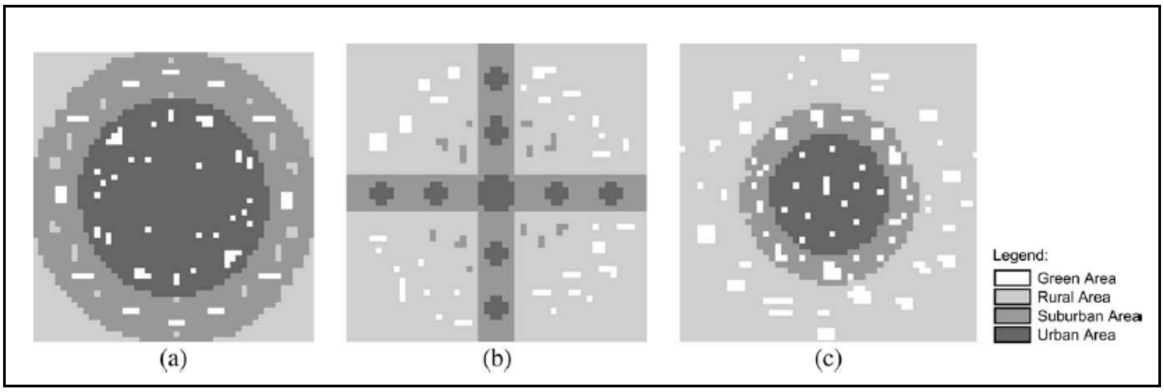


Figure 4.13: Land Use in a)Disperse City b) Corridor City c) Compact City

In his study he found the variation in the emission rate of daily VOC and NOx emission for the compact, corridor and dispersed cities. In the following table it is presented

Table 4.5: Air Pollutant Emissions Rate in Different Types of City

Daily Emissions	Compact City	Corridor City	Disperse City
Maximum Emission Rate per area kg/km2			
VOC	24.3	89.1	19.3
NOx	60.1	220	42.7
Average Emission rate per inhabitant (g/capita)			
VOC	3.93	6.56	4.04
NOx	4.32	8.61	7.40

It should also be stressed that all the cities have different ratios of VOC to NOx emissions, which are relevant for ozone formation. He concluded that these differences are mainly related to the average vehicle speed selected for each land use category.

Figure 4.14 and 4.15 present the hourly variation of the two pollutants’ maximum concentrations (relative to the background value) estimated for each city domain. Although there is a similar behaviour of O_3 concentrations for every city, the Disperse

City shows the highest concentration levels at the most critical hours (between 12:00 and 16:00 UTC). After this period, and during the evening, the Corridor City shows O_3 concentration values similar to those of the Disperse City. The Compact City shows the lowest maximum O_3 concentrations, even in the morning when no significant differences between the three cities were estimated. As expected from photochemistry, the highest

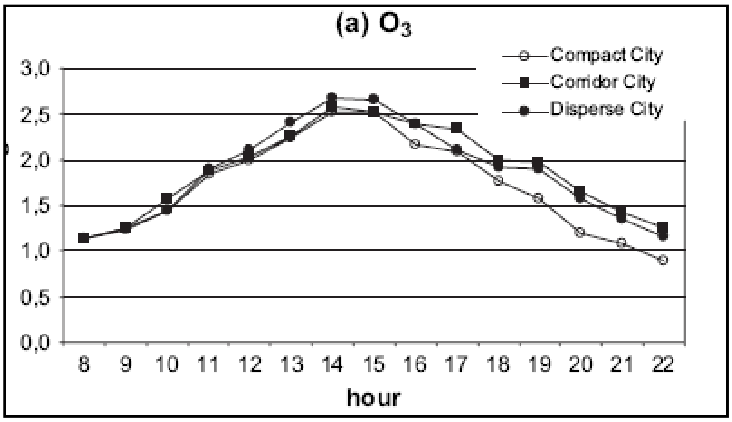


Figure 4.14 O_3 Concentration in Different Spatial formed Cities

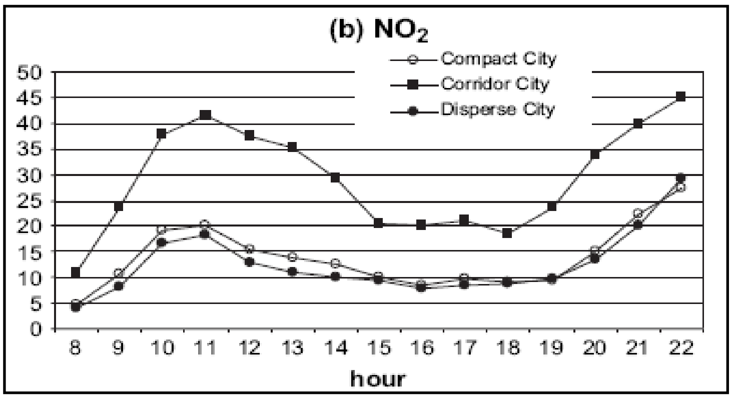


Figure 4.15 NO_2 Concentration in Different Spatial formed Cities

concentrations in all the three cities are reached at around 14:00.v. The NO_2 hourly variation is similar for the three cities, with higher concentration values in the morning and at the end of the day as a result of the photochemical cycle. The Corridor City reaches significantly higher concentrations in comparison with the other two.

Finally Borrego et al (2006) concluded as the Corridor City is characterized by highest emission rates, while the Disperse City demonstrates the lowest emissions per area and the Compact City is characterized by lower emission rates per inhabitant (Borrego,2006).

From the above discussion it is clear that the city structure has influence on the transportation emission at different scale and different levels. To generate any policy concerning air quality and GHG emission the facilitation or impediment of urban structure should be carefully drawn out. From the discussion it is evidenced that the facilitation and impediment concerning the emission in relation with urban structure are usually taken place from the pattern of trip generation, trip length, speed, acceleration and technology. In case of generating any policy to improve the situation there should have to think the casual linkages concerning the adopted policies. For example it is evidenced in the discussion that compact urban structure is favourable in term of consuming less energy. On the other hand this urban structure in saturated condition generates traffic congestion that is not in favour of maintaining good air quality. To come out from this situation a policy can be to provide more land use in suburbs to ease the congestion in Central core. The idea is very straight and forward. The relationship is very linear that is the vehicle would have less congested condition and corresponding lower emissions. This type of relation just neglects the lot of other implications that should be considered in urban planning. The issues are: 1. Most central core areas have little extra capacity at pick times and the resulting congestion is an important reason why public transport is a major proportion in the modal split. 2. More central core, freeways and bypasses would ease traffic congestion in the short term making vehicles less polluting but the large proportion of travel that can shift from public to private transport would mean such road would rapidly fill to capacity again, thus a new equilibrium would be reached with high number of polluting vehicles. 3. More suburban centre means much less potential for public transport as centralized location are easy to service thus suburban centres can easily become just as congested as central core area without the potential for public transport to ease the congestion (Lyons et al,1990) .

So in any condition it is better to take the initiatives to alter and modify the situation rather then to create a new situation. The issue of urban structure should be studied and analysed in same manner. It appears that the upgrading of public transport to city centres will have a more significant contribution to the overall lowering of emissions than to try to create less congested traffic conditions through dispersed land use or more road provision (Lyons et al, 1990).

c. Floor Area Ratio:

Floor Area Ratio is a tool that is used to control the development of a certain area. It is also related with the zoning regulations. In some cases the FAR and zoning are applied simultaneously. In a very general way the application of FAR has no specific relation with the air quality management and emission control of a certain area. The application of FAR with an object to promote specific land use or to control other land use in relation with adjacent land use has some major implications in case of controlling air quality. FAR as regulatory development tool can be applied to achieve the objectives related with application of urban density and urban spatial structure in case of maintaining air quality and emission. As a development regulation tool the implication of FAR are supporting to the other planning tools that are usually applicable in the field of air quality management and emission control. In the following diagram this relation is shown.

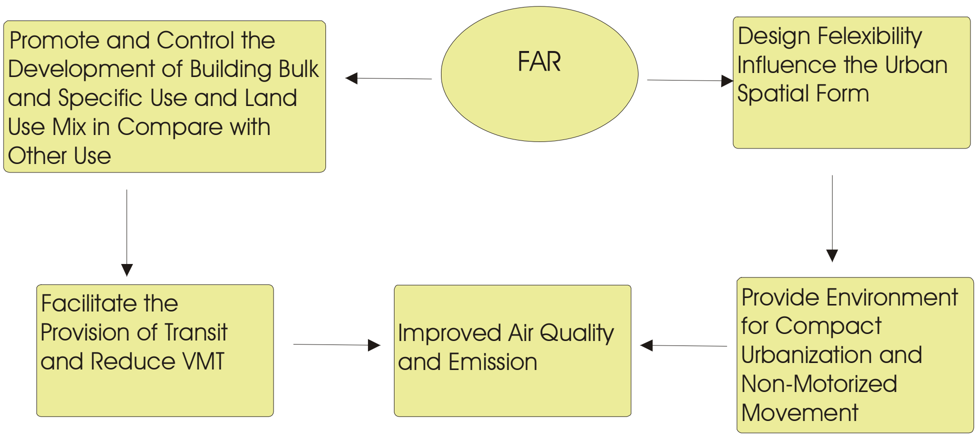


Figure 4.16: Hypothetical Influence process of FAR against emission (Source: Author Derived

c.1 Land Use Mix and FAR

The combination of floor area ratio with mix used strategy as urban planning tool is a very effective tool to reduce the VMT as well as emissions. Land Use Mix refers to locating different types of land uses (residential, commercial, institutional, recreational, etc.) close together. This can occur at various scales, including mixing within a building (such as ground-floor retail, with offices and residential above), along a street, and within a neighborhood. It can also include mixing housing types, so an area contains a variety of demographic and income classes. Such mixing is normal in cities and is a key feature of New Urbanism (Litman, 2010).

Increased land use mix tends to reduce the distances that residents must travel for errands and allows more use of walking and cycling for such trips. It can reduce commute distances (some residents may obtain jobs in nearby businesses), and employees who work in a mixed-use commercial area are more likely to commute by alternative modes (Kuzmyak and Pratt, 2003). Certain combinations of land use are particularly effective at reducing travel such as incorporating schools, stores, parks and other commonly-used services within residential neighbourhoods and employment centres. This creates urban villages, which are walk able centres and small neighbourhoods that contain the services and activities people most often need.

The Application of FAR with mixed use strategy just promotes this process of this transformation. The application of FAR in this case is maximized from the incorporation of location specific treatment. Different locations with different characteristics demands different provision of FAR with the concept of land use mix. In this relation here it is mentionable the study of the city of Portland. In this study trip reduction predictions for travel impacts of development location and design factors (FAR) are used. For example, if development has a FAR (Floor Area Ratio) of 1.0, and is located in a commercial area near an LRT station, vehicle trips are expected to be 5% less than the same development in a typical suburban area. The finding of this study is represented in the figure 4.17

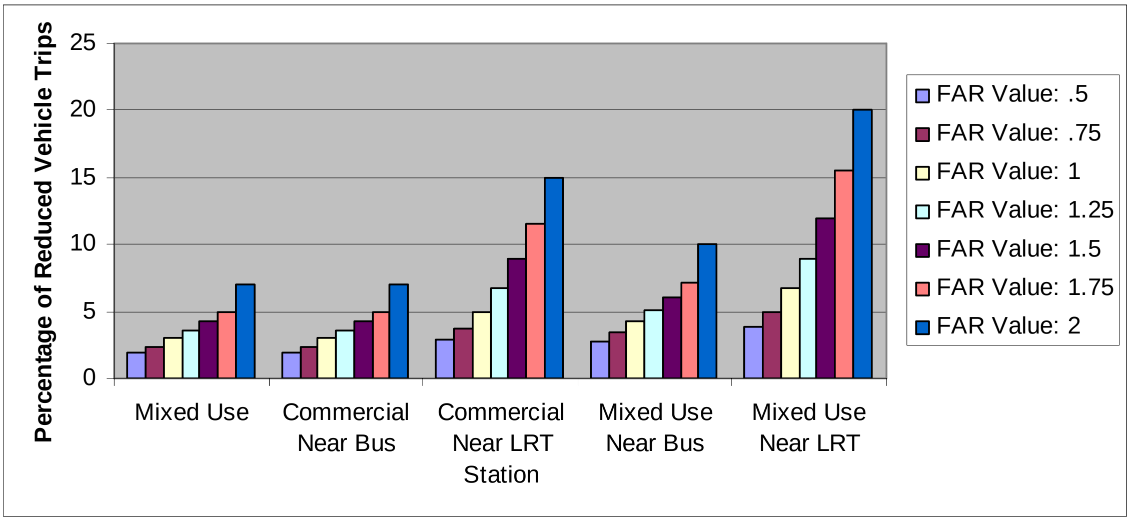


Figure4.17: Trip Reduction based on Development Location, Type and Allowed FAR
Source: Graph Generated from the Study Findings of the City of Port Land, 1995

From the figure it is clear that the increasing trend of reduced trips is resulted from the provision of increased FAR. The general trend of the reduced vehicles' trips is positive but degree and variance is location and use specific. It indicates the application of FAR with the object of trip reduction should be amalgamated with location and uses in a specific area.

c.2 FAR and Spatial Urban Form

The application of floor area ratio has some implications in relation with urban spatial form. From the point of view of scale the implications of scale can be divided in two types at individual plot scale and in large urban scale. **In neighbourhood scale** the implication of FAR is positive in response to create green environment improved air quality in an area. This is usually happen due to the allowed flexibility from the application of the FAR. In the figure 4.18 it is clear that how an individual plot can be developed in different ways. Number of development option can be exercised in case of same FAR. Due to this flexibility depends on the availability green density in a certain area the development can be controlled to provide more open space and green in an individual lot. For the improved air quality and to mitigate the heat impact of climate change this type of exercise in city development activities are really effective. Traditional design standards (height standards, lot coverage set backs and build to lines) are not able to do this. Especially in traditional system the green density is not controlled and promote where as in FAR system it is possible to do this. Green density in a certain developed area is very important from the perspective of improved air quality and to reduce the impact of climate change in urban area. On the other hand in the neighbourhood scale this design flexibility promotes to create the environment for non motorized mobility at neighbourhood level. This scheme is the comprehensive part of neighbourhood design. Provision of FAR is the part of this comprehensive design scheme at neighbourhood scale.

In Urban scale the implication of FAR is complex one in relation with its domain of influence. FAR influences the urban spatial form by influencing the market. In monocentric model it is predicted that the floor area ratios fall with distance from the central business district. The reason is that if employment were to be concentrated in the city centre, low commuting costs for sites near the city centre lead to high land value, which in turn learn lead to high FAR (Sridhar, 2010). So application of high FAR value is related with the market trend helps to promote the mocentric city structure that is friendly for the improved air quality from different perspective (already have discussed).

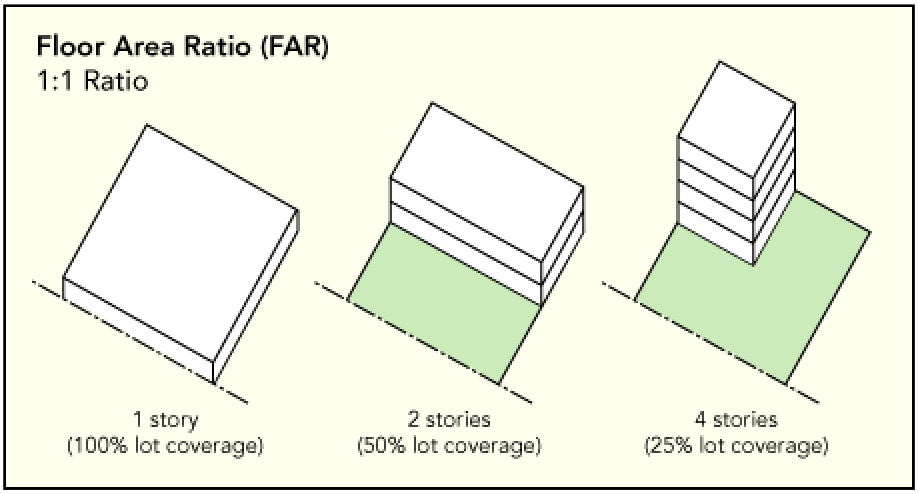


Figure 4.18: Desgin Flexibility of FAR(Souce: Los Angles Housing Department)

Not only the market trend the application scheme of FAR also influences the spatial form of the city. Rigid FAR scheme and increase FAR scheme. **Rigid FAR scheme** can only be applied in the area where the development has already saturated and there is no farther option of redevelopment. This type of FAR scheme promotes sub urbanization which is not good from the emission perspective. As Another scheme is progressive FAR scheme. This progressive increase in FAR has two purposes, as Bertaud (2004) points out; first, it allows households and firms to consume more floor space as their incomes increase without having to move to new areas in the suburbs; secondly, an increase in FAR contributes to a decrease in the city’s spatial expansion and transport costs. In this case FAR acts as a supporting planning tool to protect the sub urbanization process with other factors. On the other hand the negative forces against sub urbanization process is creates condition for compact and dense development and discourage dispersed development which are favourable condition for improved air quality and emissions control.

d. Zoning

Zoning is a regulating tool in urban planning which is usually used in land use planning. Zoning itself contains number of techniques. In a very identical way those techniques can be divided in two categories one is **land based zoning** and another one is **formed based zoning**. Land based zoning imposes some regulations directly on the land and it determines the fundamental use of the base land. On the other hand the form based zoning deals with the regulations that control and promote the form that may take on the land. Zoning as a regulation or planning tools demands multivariate discussion in respect to its domain of influence. In the case of climate change and air pollution the discussion of zoning in this case will be focused on the interactive influence of zoning in case of controlling emission and air quality. The interactive influence of zoning is supportive in the level of interaction with air pollution and emission control. Instead of indicative and or impulsive the zoning acts to promote or provide the conditional situation that helps in improved air quality and emission control. The conceptual interaction paths of zoning with improved air quality and emission control are given in the following. In the later part this conceptual paths of interaction will be discussed from different perspectives.

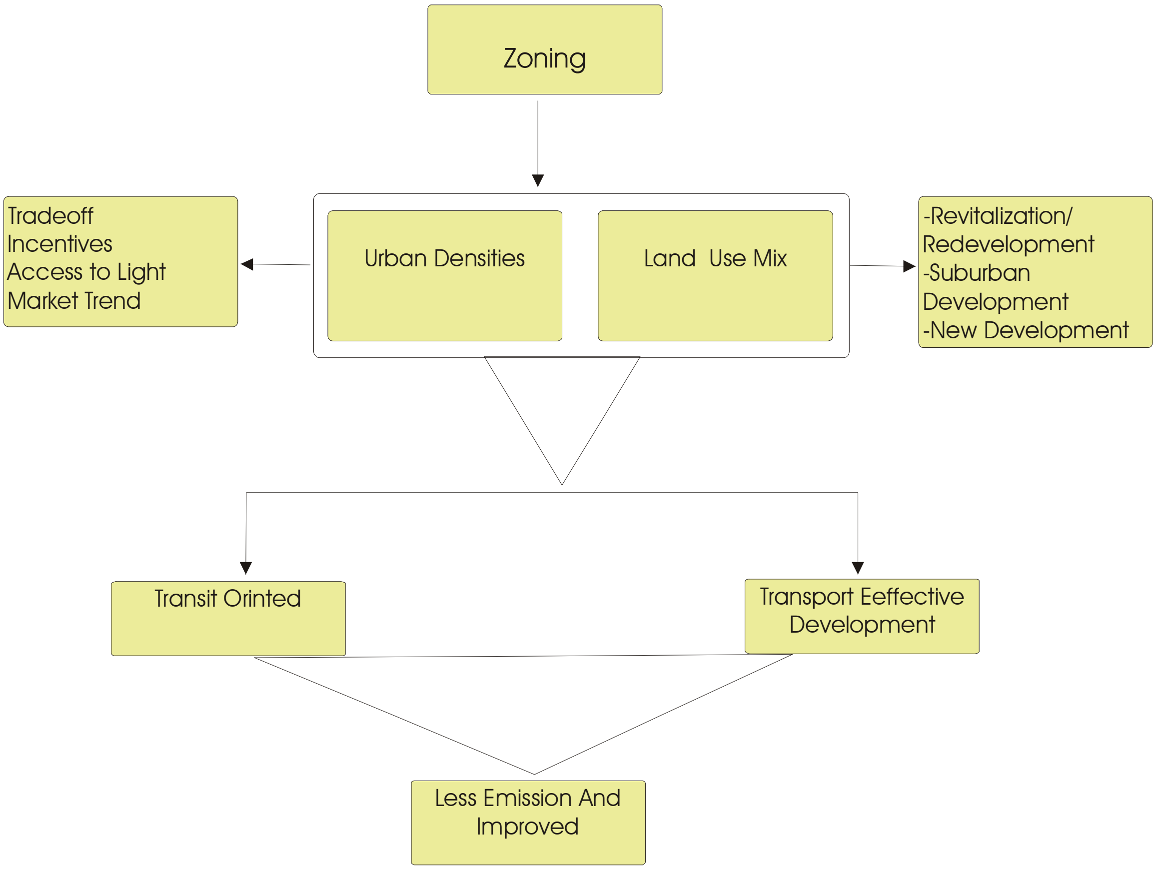


Figure 4.19: Hypothetical Influence Process of Zoning against Emission (Source: Author Derived)

d.1 Zoning and Emission

Zoning is an indirect tool to control emission and to maintain improved air quality. This indirect effect of zoning comes from the happening of two things that directly influence the transport system in an urban are. One is the urban densities and another one is land use mix. High urban densities and land use mix considered as the conditional state of the transit oriented development and transport effective development. On the other hand this type of development and promotion influence the energy consumption in transport sector as well as helps to reduce the trips generation. The resultant is the improved less emission and improved air quality.

In case of New York less emission in compare with national average is noticeable. In The average per capita GHGs production rate is 7.1 metric tons whereas the national average is 24.5 metric tons. The figure of New York is 70% less than the national average. The major cause behind this success is the zoning regulation. It is after all zoning that creates the blueprint for land development and dictates the densities and land uses that give New York City international bragging rights in the struggle to reduce carbon emissions and slow climate change (Nolon, 2007) (How does the density and land use mix promote the transportation choice and help to reduce emission- is out of scope to discuss here. Instead it will be discussed under another tool)

d.2 Application of Zoning

With the object to reduce emission the application of zoning is expected to three types of development. They are Revitalization or redevelopment scheme, suburban development scheme and new development scheme.

Most of the redevelopment and revitalization urban projects are taken over the world with the objects to increase urban tax bases, provide needed employment, reduce poverty and attract different income level residents. In redevelopment of urban projects the incorporation of the issue of climate change and emission control can give a new dimension and the application of zoning regulations with the objects of promoting transit oriented and transport efficient development can be a good way to address the application of zoning in this case.

Sub urban development context is another field where zoning can be applied with future object of promoting the transit and transport effective development. This can be applied from the prediction of the growth of population and zoning can be applied to frame out the desirable density that is required to promote and provide various types of transport services especially transit and transport effective development. Not only the density but also the mix of land uses are also important for the economics of the transit and transport effective development. Zoning can act as a direct tool to ensure land use mix in suburban context.

For any new development the matter is not so complex like the mentioned types. The careful consideration and integration of zoning regulation with the object of ensuring required densities and land use mix for transit oriented and transport effective development are the major concern in case of new development.

d.3 Zoning's Tradeoffs:

Zoning as a regulation and planning tool can be applied with the concept of intensives. From the perspectives of climate change and air quality the application of zoning is a matter of incentives. For example to ensure more green in the area and to reduce the heat impact due to climate change the provision of green roof can be promoted by giving intensive of bonus densities and development. On the other hand densities are required for transit and transport effective development. To do this the allowance of high densities by bending the height or FAR restrictions will effect in the accessibility of the sunlight. Individual lot will be suffered from the accessibility of sunlight from the adjacent lot's intensified height. On the other hand this intensive development is allowed for special purposes. So, in the overall development this tradeoffs should be considered and analysed and the major objectives and priority of the development should get the major focus in this case.

e. Urban Design Aspects

The emission sources of air pollutants and GHGs are varied. Different planning and policy tools are able to control the emission of air pollutants and GHGs at different levels. Each of the tools has their own magnitude and force to act against respective sources. The tools that have already been discussed here such as urban density, urban form, floor area ratio and zoning have their own limitation and strength to fight against the problem of air pollution and climate change. So far this is explored that almost all of tools of urban planning are work as a force to reduce the emissions from the transport. Increased VMT is one of the major responsible causes of the emissions of different types of pollutants and GHGs. On the other hand factors responsible for increases in per capita miles of travel include auto ownership; changes in demographic composition of households increase in trip distances associated with reduced density and increased separation of land uses (Frank and Pavio, 1995). With these factors emissions are also promulgated due to lacking of some design aspects at neighbourhood as well as urban level. Frank (2000) addressed some others factors related with some design aspects that are responsible for the increased VMT and emissions. He addressed the problem as the reduction of accessibility and identified the factors as the scarcity of facilities of pedestrian (i.e. sidewalks), large building setbacks and disconnected road network pattern. These changes in urban form and design components at city and neighbourhood level can influence the travel behaviour of the area which is playing a role in the rate of increased mobile emission from the transportation. In this discussion it will be tried to depict what are the design aspects that should be bring in the urban planning framework in relation with improved air quality and reduced emissions. From a transportation and air quality policy perspective, land use strategies are generally considered to be long-term approaches that are not politically viable solutions for mitigating today's traffic congestion or mobile source emissions. In the minds of many, once development is in place, it is arguably too difficult to change (McPherson, 1994). On the other hand there are several ways in which developers can design and develop their projects that will result in lower per capita vehicles emissions. In San Francisco, Ca. Cervero and Duncan (2003) observed that induce non motorized travel that is in favour of good air quality have take place due to well connected streets, small city blocks, mixed land uses, and close proximity of retail services. All of these design aspects influence the walk ability of the people in neighbourhood as well as urban scale. In the discussion the focus will be given to the context of air pollution and walk ability and the relation with the design aspects.

e.1 Walkability

From the perspective of air pollution and emission control, promoting environment for non motorized and active transportation through the implementation of design aspects are important consideration. Providing and improving the environment for walking and cycling is the best practice under this design aspect. Providing and increasing this environment for people known walkability.

Neighborhood-scale walkability relates to travel primarily by impacting proximity between destinations and directness of travel between these destinations. Proximity is a function of the density or compactness of activities and the level of land use mix (the spatial distribution of different land use types, such as residential, office, and retail). Both density and land use mix help to determine how many routine tasks—going to work, grocery shopping, visiting friends, etc.—are within a convenient distance (Frank 2000; Sallis et al. 2004). Street network connectivity—whether the street network is an interconnected 'grid' design or a disconnected system dominated by cul-de-sacs—

determines how directly one can travel between activities. Proximity and connectivity is not the only concerns in relation with increasing walkability and improved air quality. To improve air quality and walkability there will require changes in technologies, such as reducing emissions from motor vehicles, and also in urban design (e.g., land use mixing, mass transit) (Marshall et.al,2009). So to explore the design aspects at later the discussion will be focused how the design aspects such as the roadway design (proximity and connectivity), land use mix, and availability of retail use can influence the walkability as well as improve air quality. Before going to discuss that design aspects related with improved walkability and air quality and less emissions the discussion is continuing here about the relation how walkability influenced the improved air quality.

Cervero and Radisch (1995) found that residents in a pedestrian friendly community walked, bicycled, or rode transit for 49% of work trips and 15% of their non-work trips which are 18% and 11% percentage points more respectively than residents of a comparable automobile oriented community. Another study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel (Moudon, 1996). Handy and Mokhtarian (2005) also found that people tend to walk more in more walkable communities, and that a portion of this walking substitutes for driving. Some research indicates that people walk more and drive less in areas with traditional pedestrian oriented commercial districts where building entrances connect directly to the sidewalk than in areas with automobile-oriented commercial strips where buildings are set back and separated by large parking lots (PBQD, 1994).

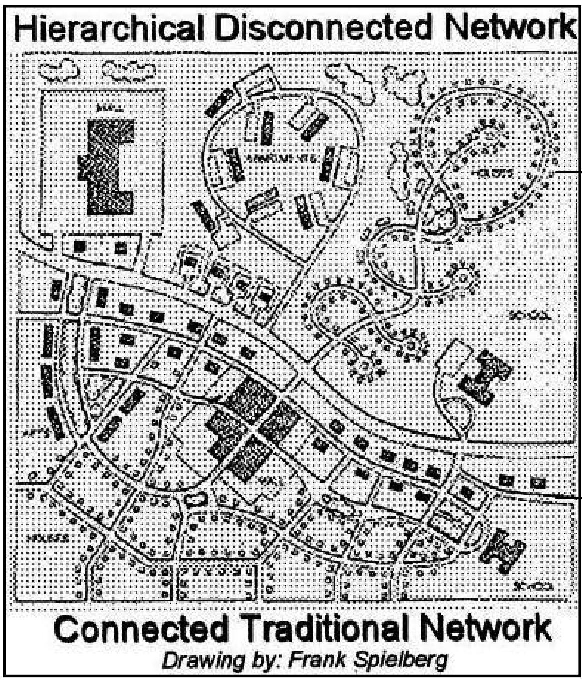
Walk able neighbourhoods (and also neighbourhoods served by mass transit) may allow people to reduce their daily travel distance, thereby decreasing vehicle emissions of NO and other O_3 precursors. A 5 percent increase in walkability was associated with 6.5 percent fewer vehicle miles travelled and 5.6 percent fewer grams of NOx emitted (Frank et al. 2006). Marshall et al. (2009) conducted a study on the city of Vancouver, Canada to investigate the pollution concentration and walk ability. They found very interesting result with in relation with the emission of the NOx and O_3. They found the positive correlation between walk ability NOx and negative correlation between walkability and the formation of O_3.This is very interesting findings as usually the high concentration of NOx air flows the high formation of O_3 as secondary pollutant. The situation of O_3 formation may differ due to the VOC sensitive regime. The existence of VOC sensitive regime can give this type of inverse results. In this relation, what is the most interesting finding here that policies designed to improve one attributes may hinder another attributes due to this inverse relationship. So in this case policy formulation in relation to increase walk ability can't solve the problem of high concentration of NOx. In case of this study the object of increasing walkability was achieved in terms of reduced VMT. On the other hand there is a problem of level of concentration and some definitive chemical process that differs in different situation. In areas with low walk ability, people often have high levels of driving and of vehicle emissions per person (Frank et al. 2000, 2006; Frumkin et al. 2004), but if activities and emissions are dispersed, then concentrations of vehicle emissions may be low (Marshall et al. 2009). Conversely, walkable neighbourhoods may exhibit reduced per-capita vehicle use and emissions (Frank et al. 2000, 2006) yet elevated traffic congestion, emissions, and concentrations if activities are highly concentrated. Ideally, one would understand all important impacts before recommending a policy action such as alternative growth patterns or transportation investments. The policy regarding increased walkability in relation with improved air quality should consider the complex relation of one component in relation with other components that are targeted to reduce for improved air quality.

e.2 Roadway Design

Roadway design can affect travel behaviour in several ways. A Connected road network provides better accessibility than a conventional hierarchical road network with a large portion of dead-end streets (Handy, Paterson and Butler, 2004). **Proximity and connectivity** are two roadway design aspects in urban design and in urban area in relation with different land uses that can change the individual travel behaviour and be able to increase walkability. Proximity is defined as the linear distance between trip origin and destinations on the other hand connectivity refers to the level of impedance or route directness associated with various travel option (Frank et al, 2000). Connectivity refers to the degree to which a road or path system is connected, and the directness of travel between destinations (VTPI, 2005). A hierarchical road network with many dead-end streets that connect to a few major arterials provides less accessibility than a well-connected network. Increased connectivity can reduce vehicle travel by reducing travel distances between destinations and by improving Walking and Cycling conditions, particularly where paths provide shortcuts, so walking and cycling are relatively direct (Dill, 2005).

In the urban design concept the presence of proximity in absence of connectivity is become a problem. Figure 4.20 represents such juxtaposition of the proximity and connectivity. In the figure the reduced connectivity of suburban street network shown in the upper half of the diagram was developed to safeguard the residential areas from "driving through" traffic. The unintended consequence of development paradigm however has been an increase in the route distance between trip ends, reducing the viability of non vehicle travel (Kulash 1990).

In a study named as LUTAQH (Land Use, Transportation, Air Quality and Health) (conducted by LFC, 2005) in King County (Seattle) Washington used parcel level land use data and trip level travel data (including VMT, travel speed, and CO_2 emissions for non-vehicle travel modes) to specifically examine CO_2 as an outcome of the land use and travel behaviour relationship. The study found the significant relationship between number of urban forms and design aspects. The study indicates that developers can increase walk ability and reduce VMT and vehicle emissions by creating a connected street network onsite and to the adjacent environs. Because road and walkway connectivity is generally determined when communities are first planned, new development presents a clear opportunity to build interconnected street networks.



Lack of Connectivity and sidewalks requires driving for travel to nearby locations. Hierarchical street network facilitates high travel speeds and reduces pedestrian safety.

Connectivity allows travel to nearby locations on foot, bike transit or by car. Shorter blocks reduce travel speeds and increase safety of pedestrians.

Figure 4.20 Juxtaposition of Proximity and Connectivity

Therefore, using connectivity as a mitigation option as indirect emission control tool is especially appropriate, since large developments will generally require building new street networks.

In the green development programme of California 9% percent vehicles trips were reduced by creating supportive environment for pedestrians and bicycles such as sidewalks, crosswalks and bike lanes, lighting, signalisation, traffic calming measures, and building entrances that are built adjacent to the sidewalk as a part of the road way design. No trip reduction is allowed under this category of mitigation if the entire area within a half-mile walking distance of the project centre consists of a single land use. The distance from the project centre is measured using an actual walking distance, rather than using a straight line distance. This takes two factors into account: 1) barriers such as freeways which are not traversable on foot; and 2) the actual street and pathway network available for walking. Figure 4.21 shows the impact that street network design can have on destinations to actual uses. Although the distances between points A and B in the two photos are about the same, the figure on the left has a much longer actual walking distance than the more connected network on the right.

Figure 4.21: Travel Distance and Street Networks (Source: LFC, 2008))

The context of reducing the trips due to high walk ability and cycling facilities are dependent in number of factors. In the formulation of policy and planning in relation with this object those factors should be also considered as a part of road way design. In the software named URBEMIS (Urban Emission) this trip reduction is designed as the function of number of factors. Most of the selection and consideration of these factors depend on individual context. To realize the extent of the factors the equation that are used in URBEMIS to calculates trip reduction are shown in the Box 4.1 .This equation shows that pedestrian factor is calculated from the number of roadway design aspects (i.e network density, sidewalk completeness, bike lane completeness)

A USEPA study (2004) found that regardless of population density, transportation system design features such as greater street connectivity, a more pedestrian-friendly environment, shorter route options, and more extensive transit service have a positive impact on urban transportation system performance, (per-capita vehicle travel, congestion delays, traffic accidents and pollution emissions), while roadway supply (lane-miles per capita) had no measurable effect.

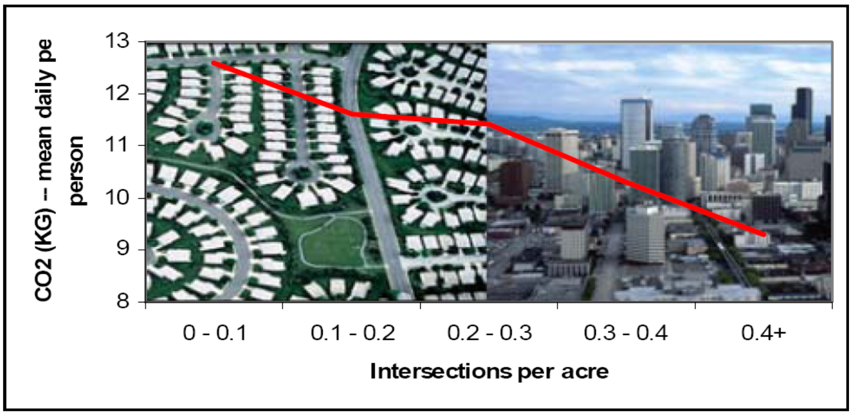


Figure 4.22: Street Connectivity and Per capita CO_2 emissions from Transport (Source: LFC, 2008)

BOX-4.1: Trip Reduction Calculation

Trip reduction = 9% * ped/bike factor

Ped/bike factor = (network density + sidewalk completeness + bike lane completeness)/ 3

Where:

• Network density = intersections per square mile / 1300 (or 1.0, whichever is less)

• Sidewalk completeness = % streets with sidewalks on both sides + 0.5 * % streets with sidewalk on one side

• Bike lane completeness = % arterials and collectors with bicycle lanes, or where suitable, direct parallel routes exist (URBEMIS users' manual p. D-27-28).

These factors are based on peer-reviewed papers; one is a meta-analysis (Ewing and Cervero 2001) that developed elasticities based on the results of over 50 studies.

(URBEMIS stands for "Urban Emissions Model" and was originally developed by the California Air Resources Board (CARB) as a modeling tool to assist local public agencies with estimating air quality impacts from land use projects when preparing a CEQA environmental analysis. The model was developed as a user-friendly computer program that estimates construction, area source, and operational air pollution emissions from a wide variety of land use development projects in California, such as residential neighborhoods, shopping centers, office buildings, etc. Source: LFC (2008)

In the study named LUTAQH in Seattle this is found that the greatest differences in VMT were observed across levels of intersection density (as compared to land use mix, retail floor area ratio, and residential density). The average VMT was 34 daily miles per person in neighborhoods with the least connected street networks and 25 miles per day in the most connected neighborhoods—a 26 percent decrease in VMT for residents who live in communities that have the most interconnected street networks in the countywide study area. Again, it is expected that these results are conservative; the use of quartiled data masks larger differences in VMT and street connectivity found in the region. Increases in street connectivity at household and employment locations were also associated with reductions in per capita levels of NOx, VOCs, and CO_2 when controlling for household income and size (Sallis et al, 2005).

Table 4.6: Relation between Intersection Density and VMT

LUTAQH ANOVA ANALYSIS (Controling for Gebder, income, age, education, total number of household vehicles distance to nearest bus stop)	Quartile of Intersection Density (1km road-network based household buffer)							
	1 (LOW)		2 (MED-LOW)		3 (MED-HIGH)		4 (HIGH)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Intersection Density (# per square kilometer)	0.00	27.56	27.78	43.35	43.37	58.75	58.75	158.93
VMT	34.03		28.83		30.01		25.46	

Source: LUTAQH study, Sallies et al, 2005

e.3 Land Use Mix

Land use mix is another design aspect that also influences the walkability and in relation to help to reduce the trips and to improve the air quality. The issue of land use mix has already discussed with another tool FAR. As the application of FAR help to organize the land use mix in certain development condition it was discussed with FAR. Here land use with respect to reduced VMT and increased walkability will be discussed referring to real study. Land use mix has been measured in a variety of different ways and seems to be especially sensitive to issues of measurement and scale. Ewing and Cervero (2001) divide land use mix measures into three types: measures of accessibility to jobs or shopping; entropy (land use diversity) measures; and jobs-housing/population balance measures.

In a detailed analysis of destinations and walking behaviour, Moudon et al (2006) states that "the walkable neighbourhood seems geographically contained within a 1-km circle, an area smaller than 500 acres (2 km^2)." Other studies which have examined land use mix at a fine-grained level such as this have found mix consistently significant in explaining VMT (LFC 2005a; Sallis 2005; Cervero & Kockelman 1997). A mixed land use pattern is correlated with increased walking and reduced automobile travel, all else being equal. A number of studies have documented decreased levels of driving in mixed-use places (Cervero and Kockelman 1997; Frank and Pivo 1995; Frank et al. 2006). In the study named LUTAQH examined the impact of individual land uses on VMT, NO_x and other emissions.

A study in the same region also found land use mix to be highly significant in predicting VMT, VHT and emissions. In applying the modelled findings, researchers found that increasing a similar index of land use mix (which included entertainment, residential, retail and office uses) from 0 (the lowest value) to 1 (its highest value) was associated with a 19.7 percent decrease in VMT, a 23.5 percent decrease in VHT and a 10.3 percent decrease in NOx (LFC 2005a)

In California the green development project also considered land use mix as a way to mitigate the emission. In the project is it considered as a development features of indirect source reduction termed as ISR. The inclusion of residential development in commercial projects and the inclusion of commercial development in residential projects, counts as a mitigation measure in the ISR. A maximum of 9 percent of vehicle trips may be reduced with land use mix as a mitigation strategy and an additional 2 percent of trips may be reduced with the incorporation of local serving retail into a project. In box 4.3 the trip reduction formula that is used in the software URBEMIS is given to give the idea of the factors that are usually considered in association with land use mix.

BOX-4.2: Land Use Mix and Trip Reduction Formula in URBEMIS

Trip reduction = (1- (ABS (1.5 * h – e) / (1.5 * h + e)) – 0.25) / 0.25 * 0.03
Where: h = study area households (or housing units)
e = study area employment

In addition to the above formula, the presence of local serving *retail* further reduces trip generation by 2 percent. The URBEMIS users' manual states that the 2 percent is a conservative amount in order to avoid double counting. (URBEMIS users' manual, p D- 21).

The above formula takes into account the ratio jobs and households outside the actual development itself, recognizing that the most significant trip reductions may result from placing a complementary use in the midst of a single-use project (for example, retail in a ***REDUCING GLOBAL WARMING AND AIR POLLUTION: THE ROLE OF GREEN DEVELOPMENT IN CALIFORNIA*** 24 residential area). The formula used by URBEMIS is from Criteron and Fehr & Peers (2001), who have used the results of over 50 studies to develop formulas that can be used to estimate the impacts of land use changes on transportation behavior. Formulas developed by Fehr & Peers have been incorporated into a number of different modelling structures, URBEMIS being one.

In the LUTAQH (Land Use, Transportation, Air Quality and Health) study in King County (Seattle) the relation between land use mix and CO_2 is shown as inversely related.

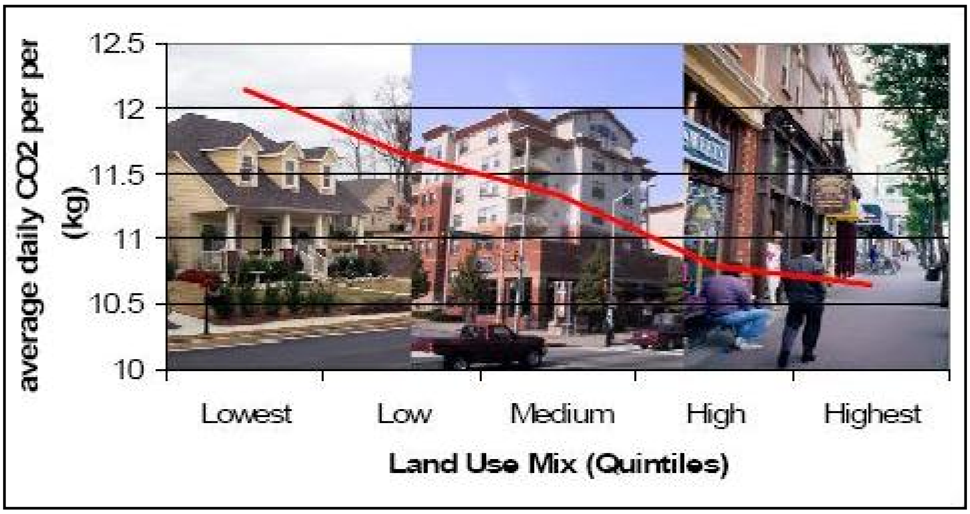


Figure 4.23: Land Use Mix and Per capita CO_2 from transport (Source:LFC,2008)

e.4 Availability of Retail Land Use

Retail land use is also part of the concept of land use mix in design aspects. In some cases such as in the absence of other land uses retail uses become a prominent one in case of studying the walkability and reduced VMT in relation with land use mix. Retail floor area ratio was subsequently incorporated into the LUTAQH study's walkability Index along with residential density, intersection density and land use mix. The walkability Index as discussed previously was found to be a significant predictor of not only VMT, vehicle emissions as well (Sallies et al. 2005). In the table 4.7 retail floor area is shown as a significant VMT predictor.

Table 4.7: Difference in VMT and Retail Floor Area. Source: Sallis et al, 2005

LUTAQH ANOVA ANALYSIS	Quartile of Intersection Density (1km road-network based household buffer)							
Retail Floor Area Ratio (Controling for Gebder, income, age, education, total number of household vehicles distance to nearest bus stop)	1 (LOW)		2 (MED-LOW)		3 (MED-HIGH)		4 (HIGH)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Retail Floor Area (building square footage/lot square footage)	0.00	0.00	0.00	.14	.15	.33	.33	3.53
VMT	30.16		30.48		30.50		25.57	

Not only as VMT predictor the retail availability, as measured by the number of retail parcels within a 1 kilometer walking distance from home, was also found to be the strongest land use predictor of carbon dioxide emissions. This particular measure, and its relationship to transportation, has not often been studied in the past – however, its ease of measurement and transferability to policy goals make it an excellent way to operationalize neighbourhood retail accessibility. In the LUTAQH it is found that mean daily transport-related carbon dioxide emissions declined slowly until a household had at least 10 retail parcels within a 1 kilometer walking distance; then emissions dropped off sharply (figure 4.24). This threshold is probably a function of increased transit service and other supportive land use/pedestrian conditions found in these places, which were not controlled in the study. In addition, it does not account for the underlying effect of residential preferences and self-selection. More research is needed to fully gauge the presence or not of this "threshold" condition. At the employment trip end, housing density, number of commercial buildings, and number of restaurants were all inversely related to CO_2 emissions.

Figure 4.24: Retail Availability and per capita CO_2 from Transport
(Source: LFC, 2008)

f. Transit Oriented Development (TOD)

Transit oriented development is not a single measure as urban planning and policy tool to solve the problem of air pollution and emission. Instead it is a package of development that incorporates the implementation of other tools some of them have already been discussed here. From the air pollution and emission control perspectives the TOD works by reducing the VMT and vehicle emissions. The basic concept is that it gives and creates an urban environment where people are encouraged to use the public transit as their major mode of transport. On the other hand it is evidenced that public transit is better in compare with cars. In terms of CO_2 emission the comparison between cars and public transport makes this clear environmental advantage of public transit. In the figure 4.23 this comparison is shown.

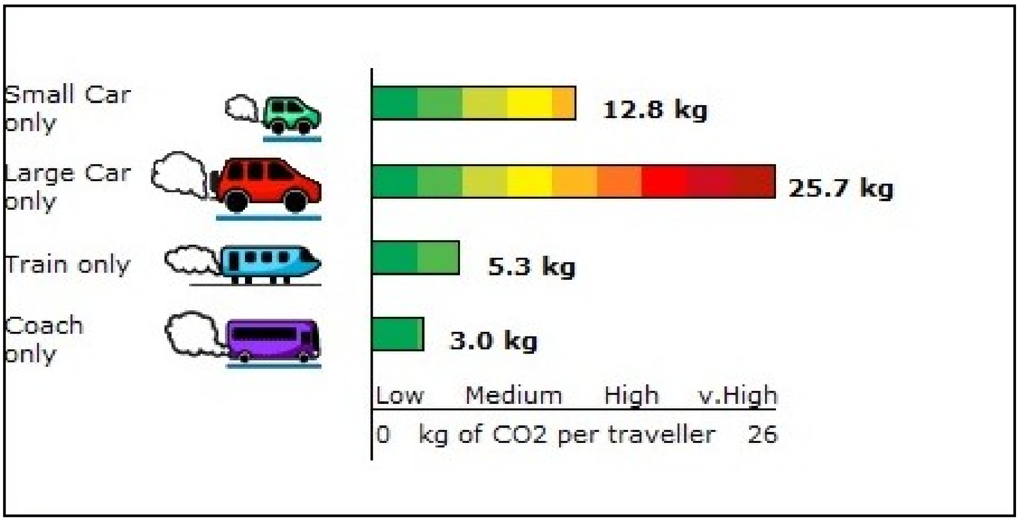


Figure 4.25: Comparative rate of CO_2emissions among different Modes of transport for 100 km travel distance. Calculation
(Source: CO_2 emission calculatorwww.transportdirect.info)

So a comprehensive mass transit system would be very effective way to help and counter the air pollution and emission problem. Obviously, if the majority of people used a public transport system instead of private vehicles, there would be less pollution produced. A solo commuter by switching his/her commute from a private vehicle can reduce CO_2 emissions by 20 pounds per day- more than 4800 pounds per in a year (Davis and Hale, 2007). The same authors stated another statistics that is also useful information to realize the contribution of public transport to reduce the green house gas and improve air quality. In case of USA in 2005, public transportation reduced CO_2 by 6.9 million metric tonnes. If in that time (2005) public transportation riders were used to personal vehicles instead of transit they would generate 16.2 million metric tonnes of CO_2. On the other hand a car occupied by one person produces on average 2.06 grams/passenger-mile (g/pm) of Nitrogen Oxides for work trips. A fully occupied transit bus, on the other hand would produce only 1.54 g/pm, while a fully occupied rail transit system would produce only .47 g/pm for the same distance. Similarly, the car occupied by one person would produce 15.06 g/pm of carbon monoxide and 2.09 g/pm of hydrocarbons. The bus would produce 3.05g/pm and .2 g/pm of the same pollutants respectively. These figures are not universal, but it impact trend and trace will be in same phase all over the world in case of public transit. Promoting transit in urban area nowadays becomes an effective tool to face and counter number of urban problems. USA is the one of the pioneer countries who is practicing the TOD in their urban development scheme. Different states are implementing TOD with different priorities with varying goals. In a USA based study different goals of TOD were weighted based on the respond of the transport agency. The result is very interesting in terms of different goals and their respective weight. In the figure:4.26 this is given to clear the application field of TOD and its influence area besides its main goals and objectives.

From the figure it is evidenced that the application of TOD is diverse in terms of stated goals. Usually this scheme is not developed focusing to a single goal. Though there are diversified goals and the small percentage stated the goal of improved air quality of TOD, transport planners often promote TOD as a way to reduce driving and redress and auto related problems such as congestion, emissions, energy consumption, inequality of access and sprawl (Cervero & Duncan, 2002). These are the all related to the environmental benefit of transit. In this section the discussion will be carried out with to find out the principles of TOD and its interrelated components.

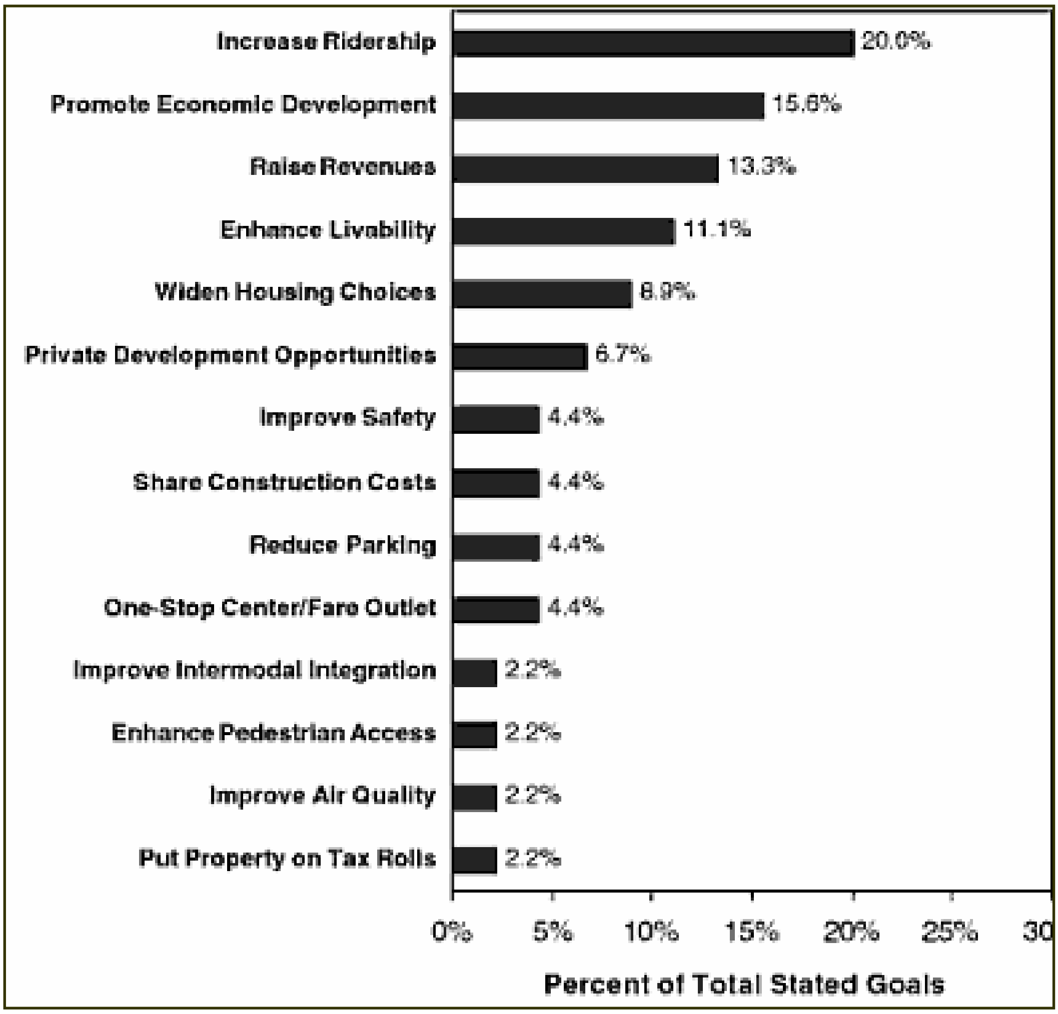


Figure 4.26: Relative Frequency of Stated Transit Agency Goals for TOD project. (Source: Cervero, 2004)

f.1 Basic Idea of TOD

TOD is known as in different names. It is also know as Transit supportive development, Transit village and Transit effective development. There found number of definitions of TOD. According to the state of California State wide TOD study,2003 the definitions of Transit-oriented Development (TOD) is moderate to higher-density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment and shopping opportunities designed for pedestrians without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use. During the early 1990s, architect and planner Peter Calthorpe added more specifics to the definition of TOD: “A Transit-Oriented Development (TOD) is a mixed-use community within an average one-fourth-mile walking distance of a transit stop and core commercial area. The design, configuration, and mix of uses emphasize a pedestrian-oriented (Calthorpe, 1990). The figure 4.27 shows the schematic planning concept of TOD by Calthorpe,1990:

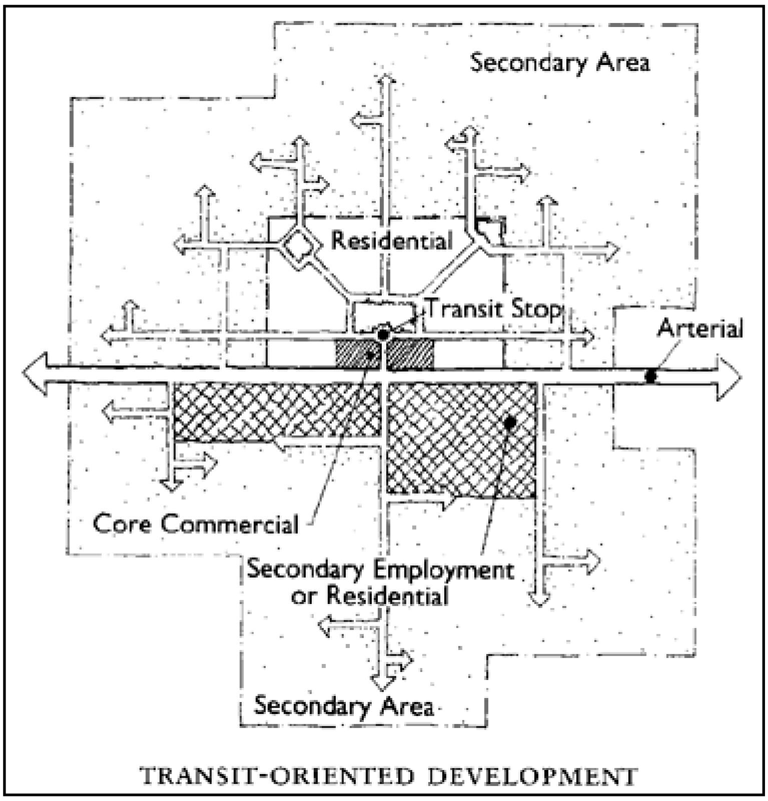


Figure 4.27: Schematic of Transit Oriented Development, Planning Concept (Calthorpe, 1990)

In TOD Secondary areas for lower intensity uses surround the core to a distance of 1600 meters. These areas might be locations for single-family housing in a range of sizes, small parks, schools, and light industry (Nelson et al, 2001). While precise definitions of

TOD will vary, it generally refers to walkable, compact and mixed use development adjacent to a transit station (TCRP, 2004).

Calthorpe (1990) further distinguishes various types of TODs based upon the **level of transit** serving them: "**Urban TODs** are located on the Trunk Line Network of the regional transit system, at light rail stops or at transfer stations, and may be developed at high commercial intensities and residential densities. **Neighborhood TODs** are located on the Feeder Bus Line Network within 10 minutes transit travel time from a light rail stop or transfer stations and should place an emphasis on residential uses and local-serving shopping. In a similar manner, TODs may be assessed on the basis of whether they are serving a neighbourhood within a community or an entire region. In the case of neighborhood TODs, the emphasis is on residential use with locally-oriented shopping in facilities that are sized to serve the population living in close proximity. Although some of the businesses may be sufficiently unique to draw customers from a larger area, most of the shops and services will be similar to those found in other neighbourhoods. Alternatively, **a regional TOD** will include uses that attract consumers from a broad metropolitan area. Examples would include: a large shopping mall; a TOD that is adjacent to a university; or a major employment centre or downtown (Statewide TOD Study, 2002). According the Calthorpe there are different levels of TOD. The development coverage of TOD is almost similar as it usually emphasis on creating walking environment. The TOD primary area is determined by the distance that a person is willing to walk to take transit. This distance is equivalent to roughly a 5 minute walk or 400 to 600 metres. At these radii around a station, there is potential for 125 to 250 acres of land for transit oriented development (Calgary City Council, 2004). Due to this catchments area strategy TOD corridors have taken the nodal form and beginning to take shape to take shape. Over 100 TOD projects currently exists in United States, found overwhelmingly in and around heavy, light and commuter rail stations. While typically nodal in form TOD corridors have taken or are beginning to take shape (Cervero, 2004); examples include the Rosslyn-Ballstone axis (figure 4.28) in Arlington Country, Virginia and Vermont western District in Los Angeles Hollyhood area.

Figure 4.28: Aerial view of Rosslyn-Ballston corridor in Arlington, Virginia. High density, Mixed Use Development is Concentrated within ¼–½ mile from the Roslyn, Court House and Clarendon Washington Metro Stations (shown in red), with Limited Density outside that Area.

f.2 Development Component of TOD

The development component of TOD is not a fix and framed. Based on the development context and trend of a particular station and adjacent area the respective development components should be planned and implemented. In this regard in the hand book of Best Practices of TOD by Calgary city Council the issue is addressed as a question and answer: How a station area is planned and developed will depend on the particular attributes of that station and surrounding community (Calgary city Council, 2004). However there are some common and key components that usually are explored to be critical to the success of any TOD. The Components are discussed in the following.

i) Zoning and defining Land Use
ii) Promote Density
iii) Create Convenient Pedestrian Connection
iv) Ensure Good Urban Design
v) Create Compact development pattern
vi) Manage Parking
vii) Make each station a place

i) Zoning and Defining Land Use

Zoning and land use demarcation go side by side in TOD development scheme. Zoning brings macro-visions of the future down to the parcel level, providing fine grained interpretation of TOD. Under zoning regulation once it is decided to embrace compact growth, a pedestrian orientation and mixed uses TOD can then be easily implemented on case by case basis (Cervero, 2004). So in a sense zoning works as the structural framework of TOD. On the other hand land use is the plot level use demarcation. But this zoning and land use demarcation practices vary from country to country. In the following the best practices are drawn from the different practices around the world.

Ensure transit supportive uses

These are the uses that attract high pedestrians in and around the developed area. On the other hand high volume of pedestrians directly promotes greater transit rider ship. They also provide opportunities for multi-purpose trips that can be made as a pedestrian. Medium to high density residential, offices, high schools and colleges are significant transit supportive uses. Appropriate retail, restaurants, personal service and civic functions will support these major uses and generate activity in both peak and off-peak hours

Discourage non-transit supportive uses

Non-transit supportive uses generate little or no ridership. They consume large areas of land, or create bleak or unsafe environments for pedestrians. They are often dependent upon a vehicle for transporting goods, or require significant land areas for low intensity development and parking. Large format wholesale stores, warehouse storage, car dealerships, auto service centres and regional sports fields are examples of uses that are not transit supportive.

Encourage a mix of uses

A mix of residential, office and supporting services in station areas can generate transit trips throughout the day. It provides opportunities for people to live closer to their jobs or to take advantage of reverse flow transit capacities. Workers can run daily errands within walking distance of their jobs; transit riders can access convenient services while at the station. Residents and visitors can continue a variety of activities in off-peak times. Locate the uses as close to the respective transit station as possible Locating a majority of transit-supportive uses within a 400 to 600 m walking distance of the transit station makes transit the most convenient and attractive travel mode for the site.

ii) Promote Density

Development densities are "as great as possible" within the context of a particular station and surrounding community. Minimum residential densities around rail stations are high enough to support higher frequency transit service and to foster lively, walkable communities. Housing forms include townhouse, walk-up apartment and high-rise buildings. Minimum employment densities are established in station areas to create a destination which generates transit trips. Table indicates some examples of minimum densities being used in LRT station areas by some cities in USA.

Density concentration and transition

The highest densities are ideally located closest to the station, to optimize transit rider convenience. This includes high-density housing and offices. Intensity of development can taper off away from the station, to create an appropriate transition and interface with the surrounding community.

Plan for density

Plans for areas around transit stations should address the ability to increase density over time. Vacant lots, surface parking lots and existing low intensity uses present opportunities for future infill development. A phasing plan that demonstrates how the station area can intensify over time offers flexibility to meet changing community needs and provides a vision for this transition.

Promoting mixed use densities with walkable environment in the focus area of TOD has positive impact on transit ridership. Cervero, et al. (2004) develop a model for predicting the effects of increased residential and commercial density, and improved walkability around a station on transit ridership. For example, increasing residential density near transit stations from 10 to 20 units per gross acre increases transit commute mode split from 20.4% to 24.1%, and up to 27.6% if implemented with pedestrian improvements

Table 4.8 :Recommended Residential Density Threshold for TODs

City Source	TOD Type	Minimum Residential Densities (Dwelling Units/acre
San Diego TOD guidelines	Urban TOD (Light Rail Served)	25 (18)
	Neighbourhood TOD (Bus served)	18 (12)
Washington County, Oregon (Land Use, Transportation and Air Quality Study)	Urban TOD (Light Rail Served)	15 (7)
	Neighbourhood TOD (Bus served)	8 (7)
Portland Tri Met TOD guidelines	Light Rail Served TOD	30: 0-1/8 mi 24:1/8 - 1/4 mi 12: 1/4 -1/2 mi
	Bus Served TOD	24:0-1/8 mi 12:1/8-1/4 mi

Source: Cervero (2004) Original Source: Community Design + Architectural Model, Transit oriented district overlay Zoning Ordinance (Oakland:2001)

iii) Pedestrian Route Design Considerations:

In TOD the pedestrians' route design should follow the following principles:

➔short

➔continuous

➔direct

➔Convenient

Walking distances are short

Pedestrian routes between the station and key destinations are short and direct. Key destinations are located within a 400 to 600 meter radius of the station. Circuitous routes are avoided.

Pedestrian connections are continuous

Sidewalks and pathways are continuous routes that are easy to find and follow. Major connections to the station for pedestrians and bicycles are constructed at the outset. Routes are universally accessible to wheelchairs, strollers, scooters and other mobility aids.

Access is direct

Sidewalks connect directly to the entrances of the station and buildings. Bus stops are located as close as possible to building entrances. Walking distances from the station to the nearest bus stop are generally shorter than the distance to the nearest parking space.

People are at street level

Pedestrian routes are at ground level, with minimal stairs and grade changes. Adjacent buildings provide "eyes on the street" and informal security here. Pedestrian routes are located on public streets unless there are good opportunities to tie in to a safe, existing above-grade system (e.g. Plus-15).

Separate vehicular and pedestrian functions

Vehicular and pedestrian ways are designed to minimize points of conflict. Sidewalk and pathway routes have as few driveway or parking lot crossings as possible.

iv) Ensure Good Urban Design

Create high quality streets

A pedestrian-friendly street is visually interesting and makes walking enjoyable. Trees, landscaping, wide, separate sidewalks and on-street parking protect people from vehicle traffic and create a pleasant pedestrian zone. Benches provide places for people to rest and relax.

Make the most of architecture

Architectural variety on the lower three to four storeys can define an interesting public realm. Articulated building facades incorporate attractive windows and varied architectural elements, and are built to the sidewalk. Upper floors of tall buildings can be set back to allow sunlight to reach the street and help reduce the sense of scale of the building.

Relate the ground level to pedestrian uses

Foot travellers tend to relate to the ground storey of buildings. This level accommodates residential units, building entrances and retail shops oriented to the sidewalk. Surface parking lots, parkade accesses and blank exterior walls are limited along major pedestrian streets.

All season design

Where possible, pedestrian connections and transit waiting areas provide weather protection in the form of awnings, building projections and colonnades. Ample enclosed shelters make waiting for transit more comfortable.

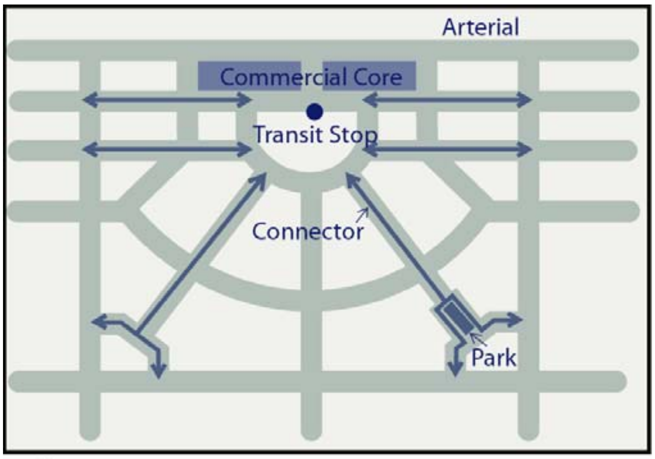
Lighting, landscaping, and signs

Stations are well-lit and designed to accommodate "around-the-clock" activity. Landscaping features can define special precincts and encourage transit patrons to linger and explore the station area. Convenient and legible signs orient visitors to buildings and activities around the station

V) Create Compact Development Pattern

Compact Street Network

Frequent, interconnected streets increase the efficiency of transit circulation and offer more choices for pedestrians. Blocks of 100 to 150m in length keep walking distances short and provide alternative route options. A grid based street pattern offers multiple accesses to the station and forms the overall development framework for long term transit supportive uses. In this relation the adopted form by Calthorpe,1990 is mentionable (figure 4.29)



Calthorpe, 1994

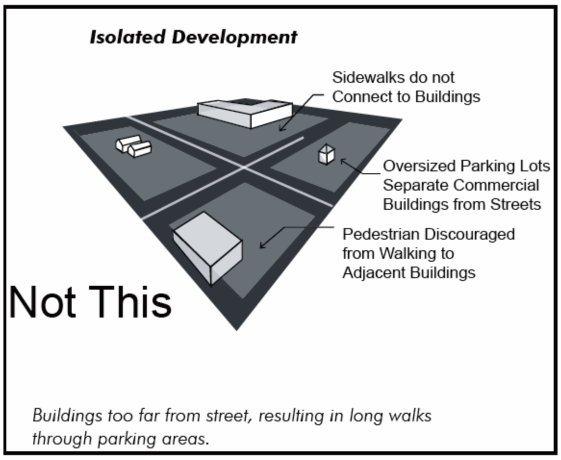
Figure 4.29: Street System of TOD by Calthorpe

Cluster buildings

Buildings that are grouped together, or clustered, offer a "one-stop" opportunity to conveniently access a variety of destinations on foot. Clustered buildings can frame distinct character areas and create an easily navigable walking environment. (figure 4.30)

Leave room to grow

Buildings can be thoughtfully sited on a property to accommodate future intensification. Placing buildings to one side of a parcel, instead of in the centre, leaves sufficient land that can be developed later. This will allow an initially low density area around an transit station to intensify over time.



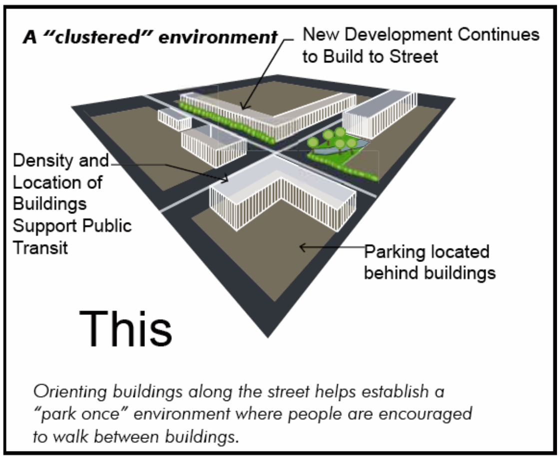


Figure 4.30: Practices of Building Clustering in TOD (Souce: Calgory City Council)

VI) Manage Parking

Accommodate the automobile

By design, TOD lessens the need for automobile use in a station area. However, accommodating vehicles is still critical to the success of a vibrant TOD district. Convenient parking and drop-off zones need to be planned for in all station area plans.

Parking - enough, but not too much!

TOD provides an opportunity to reduce the amount of parking in the station area through increased transit riderships, reduced residential vehicle ownership and shared off-peak parking at public Park & Ride sites. Setting both minimum and maximum parking standards can help ensure the success of a station area as well as optimize transit ridership.

Locate parking to the rear and sides of buildings

Parking lots are located at the periphery of the station area and to the rear or sides of buildings. This keeps the station and building entrances oriented to the sidewalk and to pedestrian users.

Smaller parking lots

Surface parking areas do not overwhelm a station area. Larger parking lots can be divided into smaller lots and separated by landscaped walkways. These smaller lots also create an internal movement network and establish a framework for longer term intensification.

Phased parking from surface lots to structures

Structured parking consumes less land than surface parking and allows maximum development. Station areas are designed to allow for the evolution of parking from surface lots to parking structures. If parking structures are located along key walking routes, they can enhance the public environment with pedestrian-friendly facades.

Bicycle parking

Bicycles can extend the local commuting range beyond the typical 600 m. Ample, convenient and secured bicycle storage locations are provided at each station, close to the entrance of the transit station.

VI) Make Each Station a Place

Create a Destination

A transit station is a destination in its own right, as well as a gateway to the rest of the city. A station area with a collection of unique places will attract visitors, while also serving transit patrons and the local community.

Make buildings landmarks

Landmarks create notable places and aid in local way finding. Transit stations and other significant buildings with distinctive design elements can make the area attractive and memorable.

Sightlines and views

Sight lines to and from the station help orient pedestrians to their surroundings. Views are critical for pedestrians to find their way. Sight lines can be terminated by important features such as the station, a community building, monument or public art.

Orient buildings to the street

Buildings that are adjacent to and overlook public areas create a visually interesting and safer pedestrian environment. Buildings oriented towards the street edge can enclose important vistas and shape the public realm.

Public open spaces

Open spaces near an LRT station emphasize the station as a public place. They provide comfortable waiting and drop-off areas for transit users and act as central activity and gathering points for the local community. The station area can be strategically punctuated with small parks or plazas, which might incorporate fountains or other landmark features.

4.1.1.2 Travel Demand/System Management

So far the different urban planning tools that are discussed were covered under the land use strategy. Almost all of the land use strategies concentrated and focus to the emission problem from the traffic. All of the land use strategies imply secondary effect in transportation sector to solve the problem of air pollution and emission at city level. All of the tools implemented in different levels of urban system that influence the land use and as secondary impact of those tools act against the problem of air pollution and emission. Here the discussion will be focused to the travel demand management that directly applied in transport sector and have indirect impact on air quality and emission. Around the world there are number of cities who are exercising the TDM techniques to solve the problem of air pollution and emission at city and regional level. From an ordinary perspective TDM can be defined as a way to manipulate the demand and supply of the transportation in a certain time. The idea is to maintain the harmony of demand and supply of the necessity of the mobility of the people. It is considered as transportation policy rather than urban policy. Transport itself is the major system of any urban area this is why this tool is discussed here under urban planning tools against the problem of air pollution and emission.

a. Why TDM in case of Controlling the Emission

The linkage between transportation and air pollution and emission problem is as a result of GHGs and other pollutants' emission. In road mode the over reliance on fossil fuel as major source of energy in automobile aggravates the emission level and consequent air pollution and climate change effects. Transportation continues to be a major source of air pollution; in the United States, on-road transportation sources are responsible for 27 percent of VOCs emissions, 35 percent of NOx emissions, and 55 percent of CO emissions (NEIAPETD, 2002). Generally, the research found that many different types of transportation strategies are available to reduce emissions, including a range of TDM measures, as well as system management approaches (e.g., traffic flow improvements, incident management), vehicle technology strategies, and non-road strategies. Some of these strategies, particularly technology-focused strategies, such as retrofits for diesel engines, can be targeted to reduce specific emissions and will result in different impact on different pollutants. For instance, diesel oxidation catalysts (a common retrofit for older trucks and construction equipment) reduce PM emissions but have no effect on NOx emissions. Biodiesel blends have been found to reduce emissions of VOCs, CO, and PM, but lead to slight increases in NOx. Understanding the impact of strategies on multiple transportation-related pollutants is important since not every strategy equally reduces every pollutant and, in some cases, a strategy may produce mixed results (reducing some pollutants while increasing others). In contrast, TDM strategies that cut vehicle travel will reduce emissions of all pollutants. Each mile that a vehicle travels, it releases more pollution, so decreasing vehicle travel mileage will lower emissions of all pollutants of concern.

b. How does it Work to Control Emission

In such condition Travel Demand Management (TDM) can be a good way to reduce the emission of transport sector as an integral part of urban area development and management. The demand of transport will grow faster than the population and GDP in most developing countries (World Bank, 1996). The Bulk of this demand will be on the road with increased number of vehicles miles travelled. The result of this process is the more emission and pollution. TDM is the best policy tools to face this problem. TDM strategies reduce motor vehicle emissions primarily by decreasing vehicle miles travelled, which can occur in several ways, including:

• Shifts from driving to other modes, such as transit, bicycling, or walking;
• Increasing vehicle occupancy through carpooling or vanpooling;
• Eliminating vehicle trips, through telecommuting, compressed work weeks (working four 10-hour days instead of five 8-hour days), or providing on-site services;
• Reducing vehicle trip lengths, such as through better urban design and land use mixing; and
• Linking vehicle trips or combining errands.

In an aggregate way it is said that the basic of TDM relates to general transportation policy as a function of supply and demand. It is aimed at reducing individual transport and change transport demand types. Capitol investment decisions and new technological developments are beyond the scope of TDM but may affect TDM performance in materials ways (Farguson, 1998). System operations and pricing policies influence TDM more directly and are in turn more directly affected by TDM. TDM may be viewed as pure marketing or the provision of information on choices and alternatives of which consumers may not be fully or correctly aware. According Farguson (1998) major element of any TDM program is to change travel behaviour in certain ways to achieve particular policy and planning goals. Again travel behaviour is influenced by controlling vehicle usage or vehicle ownerships. Specifically, TDM programs may focus on changing aspects of travel behaviour that are associated with **time, space and travel mode**.

The application of TDM strategies differ according to the context of the area of application. In different context the TDM works in different ways. There are number of

TDM techniques some of the commonly used techniques are given in the following table. In a very general all of the TDM techniques are objected to do two things one is to vehicle ownership control and vehicle usage control. In the flowing TDM strategies, example and basic goals are ordered and respective basic objectives and influenced components are indicated to frame out the working method of TDM.

Table 4.9: TDM Strategy, Examples and Objectives (Source: Grant et al, 2007 and Author Derived)

TDM Strategies	Examples	Basic Goals	Influence Dimension
Ridesharing Programmes and Investment	Park-and-ride facilities High-Occupancy Vehicle (HOV) lanes Rideshare matching programs Carpool/vanpool incentives	Reduced Individual vehicle usage	Travel Mode
Bicycle and pedestrian programme and facilities	Bike paths, bike lanes, bike routes Bike racks, bike lockers, attended bike parking Lockers and showers Sidewalk improvements, crosswalk improvements	Reduced Individual Vehicle usage	Space and Travel Mode
Transit Project	Transit service expansion Improved transit operations (busways/bus rapid transit/signal prioritization for transit vehicles) Shuttle and feeder bus service Improved transit information and amenities Transit service (rail-bus) integrat	Reduced Individual vehicle usage and vehicle ownership.	Travel Mode
Parking management	Parking pricing/fees Preferential parking for carpools/vanpools Parking supply limits	Reduced Vehicle ownership	Travel Mode
Employer Based Program	Flexible work schedules Telecommuting Compressed work weeks Employer-provided transit passes Guaranteed ride home programs	Reduced vehicle usage	Time
Public Education and Outreach	TDM outreach programs (employer marketing, media campaigns) Episodic (spare the air/ozone action day) programs	Mass awareness programe	Time, Space travel mode
Pricing	Road pricing/congestion pricing Pay-as-you-Drive insurance	Reduced vehicle usage	Time, space and travel mode
Integrated Land use and transportation planning	Transit-oriented development Design standards		Travel mode.

Most TDM programmes are holistic in nature, combining elements of all three travel behaviour paradigms as potential foci for marketing efforts aimed at managing observable changes in consumer attitudes, preferences and choice (Farguson, 1998). As it is a holistic approach it has clear linkages with other urban planning tools that have already discussed. From the emission and pollution control perspectives it works by reducing VMT and easing traffic congestion. Reduced rate of VMT is directly related to the GHG emission and air pollutant. On the other hand reduced congestion ensure smooth speed of the traffic that also reduced the emission of different air pollutant (i.e NO, CO VOC etc). On the other hand different TDM techniques are primarily influenced by the different urban planning tools such as urban density, compact urban form, zoning, urban design aspects and TOD. As all of these urban planning tools have traceable impacts on the air quality improvement and emission rate. On the same way those tools are able to influence the time, space and travel dimension of the urban transportation system. As a result the application and adoption of any TDM techniques should be interlinked and considered with those tools.

4.1.1.3 Urban Livelihood Improvement Strategy

In case of air pollution and climate change the livelihood is an important consideration for two reasons. One is for the influences of livelihood activities on the atmospheric environment and another one is the increased vulnerability and risk from the pollution and climate change hazard due to absence of better livelihood in urban area. In urban planning and policy context this livelihood improvement is a matter of consideration as the improvement of livelihood is usually concern with number of urban issues (i.e housing, income, education, mobility etc.) The scope of discussing all of those urban issues and livelihood improvement is out of scope here. Here the focus will be given to the different components of livelihood improvement and how they are related with the problem of air pollution and emissions.

Livelihoods compromise(s) the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and manage to enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Chambers and Conway, 1992). From this definition it can clearly be earmarked that there are three basic components of livelihoods that are capabilities, assets and activities. A poor livelihood can't optimally compromise among those components. Proper amalgamation and integration of these three components follows the context. The context can be rural, peri-urban or urban based. In those bases the opportunities and offer of those components differ in various ways. Among these three probable application bases the urban bases are more diverse as it holds the heterogeneous group of people and incorporate those in diverse urban system. While everywhere the livelihoods of the poor are diverse and complex, their content will vary according to the local opportunities available. Many authors suggest that livelihoods tend to be at their most complex in urban areas, with households drawing on a wide variety of activities to capture income and other resources (Meikle et al, 2001). So, urban area is a platform of the complex livelihoods in compare with other areas. In this complex bases the position of poor people are really a matter of question in terms of defining their livelihood. Their livelihood position can be explored assessing the social, economic, governance, environment and urban rural linkages. From the environmental perspectives the concern is about the way of their existing and traditional livelihood that usually affects the different component of environments. The care has to given to the capabilities, assets and activities amalgamation of the people that are giving sustainable out put for the purposes of their livelihood. Considering this basic idea of livelihood in an urban area the following livelihood strategy should be bear in mind to face the problem of air pollution and emissions.

a. Improved Housing and Livelihood

Housing condition and infrastructure facilities directly influences the livelihood response to the material assets of the certain group. Low income housing area with low infrastructure facilities in an urban area is often an important source of air pollution because of use of biomass for cooking and heating of informal burning of refuse. This type of activities has taken place due to the lacking of provision of proper and improved infrastructure and facilities. In different countries the context of this area is under multiple complexities due to the legal and political status of this area. In urban planning practices the improvement of this area should not only be focused for the livelihood improvement and poverty eradication. Instead different environmental issues should also be considered and integrated in policy formulation and strategy development. For example up gradation of slum area in developing countries usually treated as economical, social and political issues. Environmental issues are usually neglected in the up gradation of slum area. This ignorance of environmental issue in relation with their livelihood components of assets, activities and capabilities should get the focus in policy formulation. For example in this slum up gradation programme the provision of piped gas or supply of LPG cylinder in subsidised prices should be considered with priority to minimize the total impacts on the society. Due to the lack of structured cooking, burning and heating facilities in this area people usually use the wood, charcoal and other solid biomass. From air pollution and emission perspectives biomass fuel at household level badly affects the local air quality. Using biomass as a fuel produces air pollution in the form of carbon monoxide, NOx (nitrogen oxides), VOCs (volatile organic compounds), particulates and other pollutants, in some cases at levels above those from traditional fuel sources such as coal or natural gas. A study conducted Suybros et al (year: unknown) in Cambodia found that impact of biomass consumption is more severe than the consumption of LPG with respect to air pollution. The study found that the sharing of the different types of fuels such as wood, charcoal and LPG were 48%, 37% and 15% respectively. The respective emission CO, SO_2, NO_2 and CH_4 in the study area (two villages) was 277, 4665, 37, 1.84 and 268 grams per day. The study also found that the emission from biomass (firewood and charcoal) was substantially higher than using LPG .

So in the strategic development stage of policy against air pollution and emission problem the livelihood improvement should be focused to the improvement of the housing environment. In the stage of Air pollution and mitigation the up gradation of low income housing condition should be incorporated.

b. Land Use Planning and Livelihood

Land use planning is another issue that should also be considered with improved livelihood. This issue should bring in mind to minimize the vulnerability and risk of the resultant hazard of the air pollution and climate change problem. In land use and physical planning the risk and vulnerability should be considered based on the livelihood position of the certain group of people. People with improved livelihood always stay in better position against the risk and vulnerability of the different hazard. Their livelihood activities, capabilities and available assets give them that suitability. Due to poor livelihood low income people are main concern for increased vulnerability and risk of the different hazards. In urban and physical planning concern these people should get extra focus as most of them are dependent on the natural resources for their livelihood activities. On the other hand in urban scale the working group and of population should be integrated by physical, economic and social planning. Any kind of exclusion and segregation in terms of social and physical respect can enhance their vulnerability and risk. Land use planning can minimize this type of happening. Not only this, some urban areas with special characteristics (coastal city, industrial city etc) should also be treated considering the livelihood status of the people in land use planning concept.

c. Improved or Sustainable Livelihood?

Not only the conditional improvement of the housing condition in the urban development scheme but improvement scheme should also be focused to the up gradation of the total livelihood scheme of the urban people. In some development scheme this livelihood development scheme termed as sustainable livelihood (SL). SL defined as the changing nature and response, role of capability, asset (policies, environment) Households and communities react to changing circumstances, external or internal pressures or shocks, by adapting how they use their portfolio of assets and capabilities and their traditional livelihood systems. Sustainable livelihoods are derived from people's capacity to make a living by surviving shocks and stress. This requires reliance on both capabilities and assets for a means of living. A livelihood is sustainable if it can cope with and recover from stress and shocks maintain and enhance its capabilities and assets and enhance opportunities for the next generation (UNDP (A), 1997). Promoting this SL scheme is not only important from the environmental perspective. This concept has direct influence in social, economical and institutional level. During the generation of policy those levels should be integrated. One sighted focus of livelihood development is not be able to address the issue of environmental problem as well as the problem of other fields as they are interlinked with one another. In urban development scheme the livelihood improvement should be treated in sustainable way not as a separate or segregated component to solve a definitive problem. Here the issue livelihood improvement is addressed as a way to notice to its importance in the problem of air pollution and climate change not as a media of solution. Moreover livelihood programme at urban level should also be integrated with impact resilience of the climate change and air pollution. Improved and sustainable livelihood is able to protect the people from the severity of the impact of different environmental hazards.

4.1.2 Direct Emission Control UPP tools

Here the discussion will be carried on direct emission control UPP tools and the focus will be given to those tools that are objected and applied directly to control the emission.

The basic object of these tools is to protect the emission at different level. There are number of direct UPP tools in the filed of application. To scale down the discussion the focus will only be given to those tools that are applied to control the emission directly and that have direct relation with the urban physical planning and policy. There are using number of strategies as emission abatement and control tools. To clear the idea here the name and basic ideas of those are addressed. After that the focus will be given to specific tools to carry on the discussion in relation with the urban planning. The strategies that are in use to reduce or abate the emission are given in the following table:

Table 4.10: Direct Emission Control Strategy

Type of Strategy	Examples
1.Emission Reduction Techniques/Technological solution	a. Uses of Electrostatic and Baghouse filters in power house to protect the emission of particulate matter. b. Scrubbers or Fuel Gas desulfurization (FGD) to remove the emission of SO_2. c. Selective Catalytic reduction (SCR) to reduce the emission of NO_2 d. uses of low sulphur coal in industry.
2. Direct Regulation	a. Fixing standards (vehicle standards, emission standards) b. Emission Density Zoning
3.Taxation	a. Direct emission Tax b. Mitigation fee
4. Creation of Markets for tradable permits	a. Emission trade permission among the polluters
5. Provision of framework for private litigation/voluntary approaches	a. negotiated agreements between public and private organizations.
6. Subsidies	a. promote diffusion of environmentally benign products. b. reward environmentally friendly behaviour. c. Finance environmental infrastructure investment.

All of the strategies that area addressed here are directly imposed and applied with the object of reducing the emission. Most of the tools are the branches environmental policies and environmental economics. Mitigation fee and EDZ are two strategies that have close link with urban planning. In the next these two strategies will be discussed.

4.1.2.1 Mitigation Fee

The concept of mitigation fee basically stemmed out from the concept of Impact fee. Before going to discuss the mitigation fee the concept of Impact fee are going to give here. Impact fee basically deals with the development consequences. Impact fees are defined as "single payments required to be made by builders or developers at the time of development approval and calculated to be the proportionate share of capital costs of providing major facilities— arterial roads, interceptor sewers, sewage treatment plants, regional parks, etc" (Frank and Downing 1988). In USA this strategy is in extensive use to finance the infrastructure. Since the 1970s, development impact fees have emerged as a way to pass the cost of new infrastructure to the development community.

On the other hand the mitigation fee is another form of financing that formed out of impact fees are known as mitigation fees. These fees are similar to impact fees because they are a charge to the developer or a new development based on the effects the development may have on an area. The one factor that separates them from the other types of fees is that mitigation fees focus on just the environmental effects of an area. These fees are charged by local governments on developers or new development in order to reimburse the community for the negative impact that development may have on the community. In some cases these fees are used as a way to preserve a community's environment along with regulating pollution in a region. In the more recent past these fees have become more popular by the need to protect the environment for the future from negative development. Still there is debate about whether these types of fees are a legally acceptable form of government funding like impact and linkage fees are (wikipedia, 2010). In terms of environmental mitigation fees, the idea is that the development can be charged a proportionate share of the impact cost of the development on the environment or the preservation of the environment.

a. Implementation Condition

The first and perhaps the most important step in the implementation of an environmental mitigation fee programme is the inclusion of a **comprehensive environmental preservation** or pollution control programme in a comprehensive plan (Nicholas & Julian,2003). Without comprehensive development plan imposing of mitigation fee will create ambiguities among the concern parties. In some case the imposing of mitigation fee will be legally weak. If there is compressive environmental preservation and development scenario plan then all implementing actions would have to be in accordance with a comprehensive plan. In preparing such a programme or plan the initiative have to come from the national as well as local government. This institutional feature is more context oriented rather than universal basis. The basic thing is that it should have some institutional legal basis. The cities and countries those have their own comprehensive plan for certain year they have to incorporate the concept of mitigation fee in that plan. The idea is to give an institutional and legal basis to impose the mitigation fee to certain developers. The incorporation of **development performance standard** is another important thing of consideration in this incorporation process. By doing this it will be possible to calculate the nature, extent and necessity of environmental mitigation. Development performance standards reflect the nature of and the extent of the need for environmental mitigation. This mitigation requirement could be on a functional or area basis, whichever is appropriate (Nicholas & Julian, 2003).

The more difficult aspect of implementation will be first defining and then identifying the nexus between development and need for environmental protection and or preservation. If a traditional impact fee model is to be followed, some type of quantitative nexus between development and environmental impact will be needed. If new development is not on or adjacent to ecologically sensitive areas, such relationship may be difficult to establish.

Environmental mitigation requirements could only be based on the direct impacts of developments on different features. The environment is the composition of multiple features and components and the impacts of developments extend to indirect as well as direct effect. In case of air pollution and emission perspective it is much more difficult to identify the direct effect as well as indirect effects. This more expansive view of the environment and the embodied relationship between land, atmospheric disturbance and the environmental consequences offers a means for establishing a quantitative nexus between development and the need for environmental protection and preservation.

b. Mitigation fee and Urban Planning:

Mitigation fee are important consideration in urban planning as it is closely related with the development. From the above discussion it is that it doest impose it restriction on the development permission. Instead it imposed compensation as a result of consequences of certain development and to mitigate those consequences. In case of protecting the emission problem the application of mitigation fee is bit ambiguous as it is bit difficult to assess the direct calculative effects of the emissions. Instead of calculating the direct effects scenario standard performance can be applied in case of protecting the emission by applying mitigation fee. The idea is like related with the taxation imposition after certain level of emission but the difference is that there will be some scenario in relation with probable direct effects. This is very important consideration from urban planning perspective as this consideration will stimulate integration of the development impact scenario on different components of urban. Moreover the spending of the mitigation fund is matter of planning concern as they are collected to mitigate the certain impacts. In case of air pollution and emission perspective the application of mitigation fee can work in an area that has tremendous development pressure in terms of industrial use. On the other hand new development means increased VMT. So how this issue will be considered in terms of mitigation is really matter of big concern. The mitigation fee can be applied to develop the other facilities that are alternatively help to reduce the emission problem. It is not necessary that mitigation fee have to utilize in the direct field of development impact. Instead in some cases there may have some possibilities to stimulate mitigation option that has is more output oriented from environmental perspective. For example in a certain area due to the industrial development and over standard emission a certain heal problems have arose to the people. In this case the mitigation fee of the will be the treatment facilities of the suffered people. But this type of direct application view of mitigation fee has some scope to be altered. Instead of meeting the health hazard problem the mitigation fee can be fixed from the same amount of emission cutting calculation in other filed (i.e transport: development of TOD, increase walk ability etc.). All of those issues are directly related with the comprehensive planning and there come the issue of urban planning.

4.1.2.2Emission Density Zoning:

Emission Density zoning (EDZ) is an air pollution control strategy that is similar to traditional land use zoning. EDZ controls air pollution by setting emission density limits (EDLs) for certain areas of land. EDLs restrict the rate of pollutant emission per unit area. Setting EDL is the major fact of technical concern of EDZ strategy. EDZ arose as an alternative strategy of the source-by –source air pollution control. Source-by-source controls have certain limitations once a particular emission threshold is reached, reducing pollutant level below the threshold becomes very expensive or even impossible due to the limits of technological controls. Such schemes are designed to avoid high pollution levels by placing upper limits on emissions over a geographical area, as opposed to placing limits on individual pollution sources. The generally accepted definition of EDZ is a type of of air pollution control regulation in which the maximum legal rate of emission of an air pollutant is based on location, land area, land use and air quality constraints (Norman et al,1978).

Emission density Zoning (EDZ) is used to cover a widely varying group of different land use based air quality management strategies. The term is also known as emission allocation, Emission Allocation Planning and District Quotas. Environmental Protection Agency (EPA) defined EDZ as air quality maintenance strategy which requires that emissions of a pollutant be limited to the prescribed levels for a selected unit area. The term might be more properly described as Unit area emission quota. The pollutant limit would be developed in terms of an amount per unit area per time period specific to a particular land use category. For example, an EDZ regulation might specify that heavy industrial land uses seeking to construct in a municipality must emit no more than two tons of particulates per acre of lot size per year. Hence a 100 acre establishment classified as heavy industry would have to certify that it would emit less than 200 tons of particulates yearly before being allowed to construct.

a. Basics of EDZ

EDZ is considered as an urban planning tool to discuss as it works similar to traditional land use planning and zoning. The defined mechanism directly works to reduce the air pollutant in a certain area. EDZ is the combination of zoning, land use planning and EDZ itself. The idea is to earmark an area with certain zoning and land use regulation with an additional restraint on how each land area may be developed. Each hectare is assigned an emission density limit (EDL) which specifies the maximum emission is allowed per unit of time per unit of land area (for example grams of particulates per second per hectare).

b. Applicability of EDZ

EDZ can be exercised on already developed area as well as already planned area. It is possible to apply in an area that have already planned and zoned with different land uses and functionality. In a planned area the efficiency of the particular land use may become as a question. To overcome this type of question the best practice is to assign or fix EDZ during the preparation of land use plan and zoning. The emission limits would off course be different for different types of pollutants. They may also vary within same regions depending on meteorological condition, current air quality, development patterns and development trend. EDZ not only limits the emissions it also helps to limit the development boundary by fixing the emission. For example if an area is regulated and guided by EDL, it means that the area can't exceed that limit. So when the area started to develop and will continue to develop it can only go to that limit of EDL. This is a very effective case to control the development of industrial city in an environmental friendly way.

4.2 Integrated Effect Based (Air Pollution and Climate Change) Urban Planning and Policy Tools:

At the interaction and integration level the air pollution and climate change it is already discussed that the pollutants of air pollution has no significant impact on the GHGs emission that are causing climate change. On the other hand the global consequences of climate change in local level is become a concerning issue in nowadays. Here the discussion will be carried out to find the impacts of climate change and its influence on air quality at city level. Then some planning and policy tools will be discussed against the framed problem.

a. Impacts of Climate Change at City Level and Air Pollution

There are number of literatures that addressed the issue of the impact of climate change at city level. The focus only will only be given to the impacts that influence outdoor air quality. The impacts of climate change is expressed at city level through the changing of temperature, flooding, scarcity of natural resources due to high demand causing from the natural climatic deflation (i.e excess demand of ground water due to hot summer), health damages due to poor air quality from climate change effect, biodiversity etc. In this case the concern is about the air quality at city level. What impacts of global climate change can influence the air quality at city level. It is already shown that the increased temperature is responsible for the formation of NOx and surface level air pollution from the formation of ozone. The global increased temperature is stimulating this condition at different scale and different level around the world. This is not a direct causal relationship. Instead it is related with specific problem of the expression of different urban features. This specific problem is identified and termed as Urban Heat Island. Urban heat island is a phenomenon between micro and meso scale. Sometimes it is a problem of micro scale and some time it is a problem of meso scale. This problem is aggravated by the global scale problem that is climate change. Global climate change may intensify urban heat islands with implications for local air quality, heat stress, morbidity, mortality and energy demand (Arnfield, 2003). The hazard potential of the UHI may be enhanced due to climate change. The globally averaged near-surface air temperature is projected to increase by 1.4 to 5.8°C over the period of 1990–2100, given a range of greenhouse gas emissions and climate sensitivities to changes in radiative forcing (IPCC, 2001). Especially important are shifts in minimum average temperature, cloud cover and wind speed. Climate change has the potential to significantly alter the intensity (e.g., size and duration) and increase the spatial extent of heat islands in urban environments. As temperature warms, the frequency with which UHI conditions occur could grow (Che-ani et al, 2009). This frequency of UHI gets severe in terms of air quality during the seasonal peak time. The resultant higher temperature during this seasonal peak period (summer time) creates the excessive demand of energy for cooling energy in residential and commercial building. Increased demand means the additional electricity generation in power plant that leads to higher emissions of sulfur dioxide, carbon monoxide, nitrous oxides, and suspended particulates, as well as carbon dioxide, a greenhouse gas known to contribute to global warming and climate change (Gorsevski et al, #). Not only seasonal severity, due to climate change the persistent duration of the heat wave and UHI are getting long. Researchers already have predicted that the duration of heat waves are projected to increase in the future (Rosenzweig and Solecki, 2001). Interactions between the UHI effect and heat waves are likely to lead to increased intensity of the different effects. As a result current meteorological conditions associated with heat island intensification are also associated with intense pollution episodes in cities (NRC, 1991), higher temperatures and changes in cloud cover in the future could lead to higher rates of smog formation, and lower wind speeds may tend to keep pollutants concentrated over urban areas, with associated health effects (Che-ani et al,2009.). Lee (1993) estimates that a 1°C rise in summer air temperatures (a proxy for the amount of catalysing sunshine) is associated with a 14% increase in surface ozone concentrations in London. This partly explains the poor air quality that contributed to significant mortality during the European summer heat wave of 2003 (Stedman, 2004). The exceptional temperatures stimulated emissions of natural volatile organic compounds (VOCs), such as isoprene, from vegetation, leading to the highest recorded ozone concentrations experienced in the UK for over a decade (Wilby,2007).

b.Does UHI affect Global Climate?

Urban heat islands themselves are not responsible for global warming because they are small-scale phenomena and cover only a tiny fraction of the Earth's surface area (Vooget, 2004). However, there are some urban to global scale connections that are worth noting:

1. Approximately half of the world's population currently lives in cities, and this value is expected to increase to 61% by 2030 (UNFPA, 1999) The high rate of urbanization,

particularly in the tropics, means that increasing numbers of people will be exposed to impacts resulting from heat islands in the future.

2. Most greenhouse gas emissions that contribute to global climate change come from urban areas. These emissions therefore contribute to both local and global scale weather and climate modification (Crutzen, 2004). Further urbanization will increase emissions originating from cities. Investigation of the larger scale impacts of urban emissions is seen as an important area of future research (Crutzen, 2004).

3. The climate modifications that have occurred in large cities over the past century show similarities in terms of the rates and magnitude expected with projected future climate changes. Therefore cities may serve as a model for assessing the impacts of, and adaptation strategies to, climate change on both local and global scales (Oke, 1997).

In the next the discussion will be carried to give the basic idea of UHI and list out different tools to mitigate it from the urban planning perspective.

c. Definition and Types of UHI:

In urban areas, buildings and paved surfaces have gradually replaced pre-existing natural landscapes. As a result, solar energy is absorbed into roads and rooftops, causing the surface temperature of urban structures to become 50° - 70 °F higher than the ambient air temperatures (Taha, Akbari and Sailor, 1992). As surfaces throughout an entire community or city become hotter, overall ambient air temperature increases. This phenomenon, known as an "urban heat island," can raise air temperature in a city by 2 - 8 °F. (Oke, 1987; World Meteorological Organization, 1984).

There are three types of UHIs (Vooget, 2004):

➔Canopy layer heat Island;

➔Boundary layer heat island;

➔Surface Heat Island;

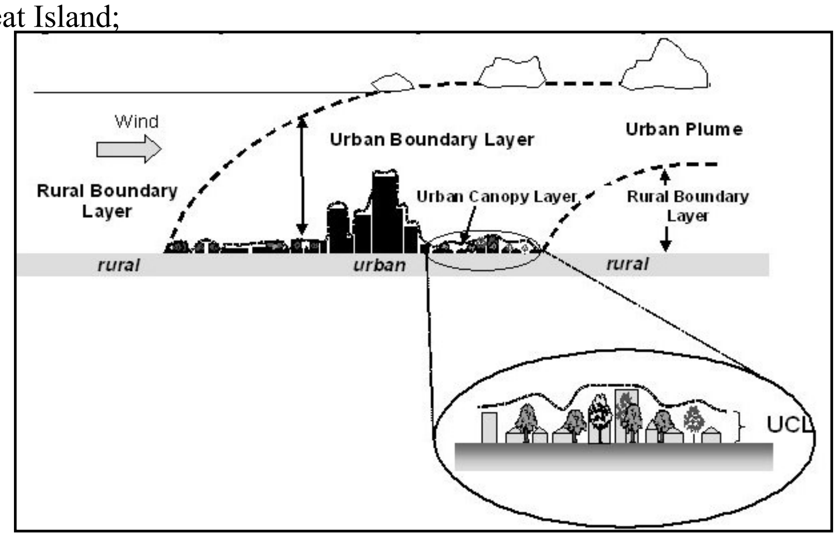


Figure 4.31:Different Types of UHI (source:Vooget,2004)

The first two refer to a warming of the urban atmosphere; the last refers to the relative warmth of urban surfaces. The urban canopy layer (UCL) is the layer of air closest to the surface in cities, extending upwards to approximately the mean building height (Figure 4.31). Above the urban canopy layer lays the urban boundary layer, which may be 1 kilometer (km) or more in thickness by day, shrinking to hundreds of meters or less at night (Figure 4.31).It is the Boundary Layer Heat Island (BLHI) that forms a dome of warmer air that extends downwind of the city. Wind often changes the dome to a plume shape.

d. Major Causes of UHI:

The following four factors are the major causes of the Urban Heat island effect (Yamamoto, 2006) (figure 4.32)

i) Increased anthropogenic heat release: Heat release resulting from energy consumption in urban areas.
ii) Changes in surface cover: reduce surface evapotranspiration capacity due to less green area. The heat storage effect of construction materials such as concrete ansd asphalt
iii) Urban structure: heat stagnation due to densely packed buildings, expansion of urban areas.
iv) Other: the green effects of fine particulate air pollution in urban atmosphere

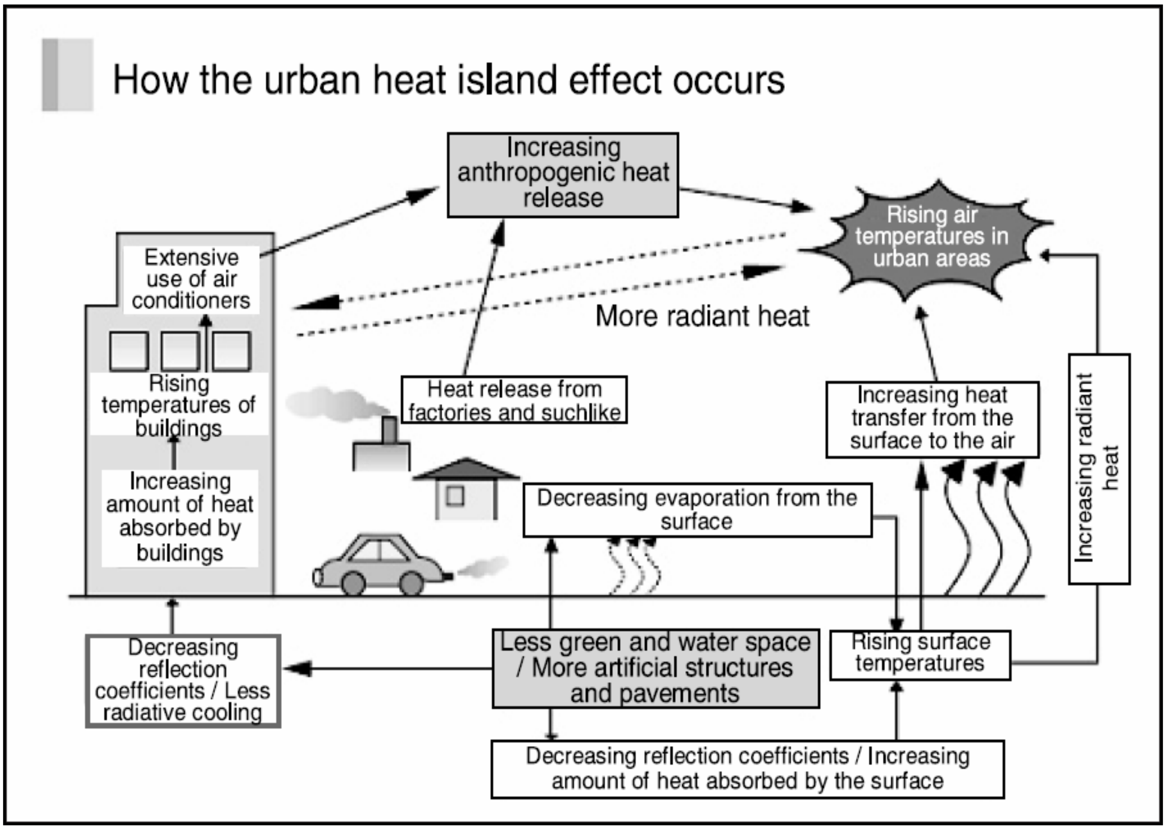


Figure 4.32: Causes of the Urban Heat Island Effect
(Source: Yamamoto, 2006)

e. Adaptation Measures of UHIs:

Through the implementation of measures designed to mitigate the urban heat island, communities can decrease their demand for energy and effectively "cool" the metropolitan landscape. In addition to the economic benefits, using less energy leads to reductions in emissions of CO_2 - a greenhouse gas - as well as ozone (smog) precursors such as NOx and VOCs. Because ozone is created when NOx and VOCs photochemically combine with heat and solar radiation, actions taken to lower ambient air temperature can significantly reduce ozone concentrations in certain areas. So mitigating UHI is a way to improve the air quality of the area and in another sense it also works to reduce the emission of GHS at urban scale. In the following some mitigation measure of UHIs are discussed from the literature of Yamamoto, 2006 and Che-Ani 2009.

From planning and policy point of view the mitigation measures of the UHIs can be framed in four broad heads. They are: **i)** reduction of anthropogenic heat release through urban activities **ii)** improvement of artificial urban surface covers, **iii)** improvement of urban structure such as the placement of orientation of buildings and **iv)** enhancement of lifestyles, in particular campaigns to encourage light clothing in summer and to reduce idling of automobile engines are both promoted as lifestyle improvements. i.e measure closely related to social and economic activities.

In the following table under this broad policy framework different measures are listed:

Table 4.11: UHI Adaptation Measures

Policy and Measure	Application Scale	Period of Application
i)Reduction of Anthropogenic heat		
a. Improvement in the efficiency of energy using product	Individual	Short term
b. Improvement in the efficiency of air conditioning system	Building	Short term
c. Optimal operation of air conditioning system	Building	Short term
d. Improvement in the heat insulation and thermo-shield of buildings.	Building	Short to medium term
e. Greening of Buildings and adoption of water retentive materials.	Building	Short to medium term
f. Improvement in the reflectivity of walls and roofing materials	Building	Short term
g. Introduction of traffic control measures	Cities and regions	Short, medium and long term
i. Used of untapped energy (use of exhaust heat from urban facilities)	Local and city	Medium to long term
j. Use of natural energy (photovoltaic generation, use of solar heat)	Building to city	Short, medium to long term
ii)Improvement of artificial surface Covers		
a. Improvement in the reflectivity and water retentivity of paving materials	Cities	Short term
b. Greening (improvements of parks and greens, street greening, greening of dwellings)	Local* to cities	Medium to long tem
c. Greening of buildings and water retentive materials	Building	Short to medium term
d. Open water space	Local* to cities	Medium to long term
iii) Improvement of Urban Structures		
a. Improvement of the orientation of the building (improvement of orientations of buildings and roads and effective use of wind and water paths) See Box 4.5 for wind paths	City block to City	Medium to Long term
b. Improvement of land use (construction of large scale parks and open space and reorientation of industrial commercial and industrial use)	City	Long term
c. Creation of eco-cities	Local to City	
d. Creation of recycling based society	Local to City	Long term

Box 4.3: Concept of Wind Paths

The concept of wind paths design is a common mitigation measure. Numbers of countries have already adopted this measure in their Urban Planning concept to mitigate UHI. Germany and Japan is pioneer among them. The basic of wind path design are described there to give the idea of this technique.

Winds that blow along paths are locally circulating winds such as those blowing from sea to land or from mountains to valleys. Winds paths bring i)bring in cool air from the sea, lowering day time urban temperatures ii)bring in cool air currents that flow down mountain slopes and valleys, cooling hot urban air at night and iii)help alleviate air pollution by bringing in generally cleaner sea winds and cool air currents.

Rivers are particularly useful in bringing sea winds. In fact that rivers can serve as wind paths is now being incorporated in urban design. Based on the orientation of the buildings along the river the effects of the vapour pressure and relative humidity on buildings are varied.

When buildings are positioned parallel to a river, they interfere with the air flowing along the river, preventing it from finding its way into urban districts. Positioning buildings perpendicular to the river, effectively channels air flow into these districts. When building are positioned 45° angle to the river however they produce two contrasting effects, depending on the direction of wind flows along the river (figure 4.33). If the buildings align with the wind, they channel it in, while they if they align against the wind they deflect it movement.

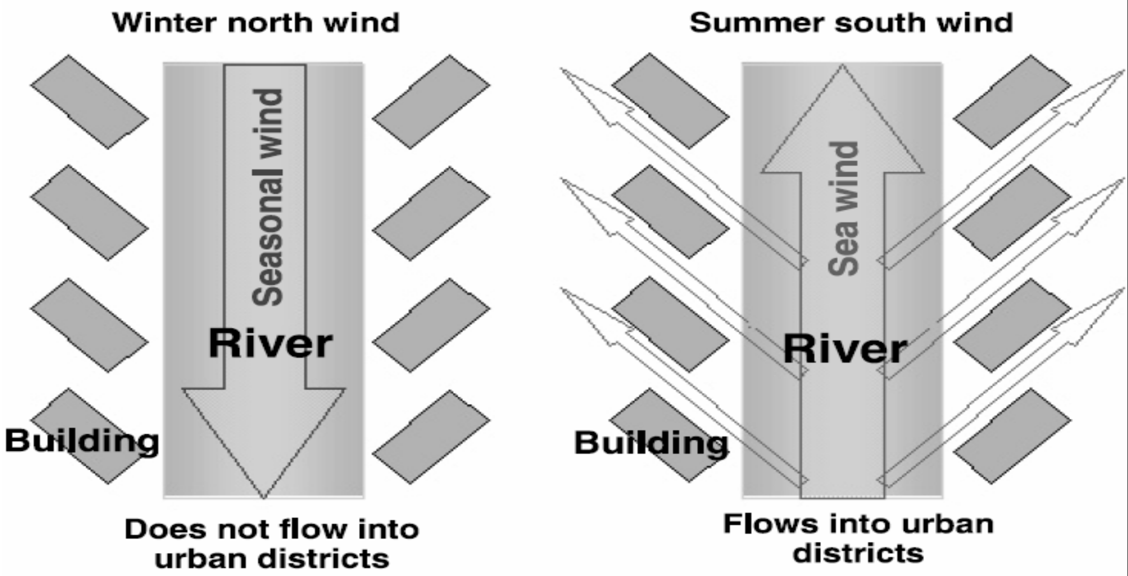


Figure4.33: Illustration of wind paths along the river

The orientation of the buildings is shown in figure channels a cool sea wind from the south in to an urban district during the day in summer, while deflecting a cold seasonal wind from the north in winter. These experimental results have shown that seasonal winds can work in two beneficial ways.

f. Urban planning and UHI Adaptation tools

It is explored that there are number of tools that can be utilized at different level to mitigate the effect of UHI. These include roof top greening, exterior wall greening, water retentive pavement and thermo shield pavement. These sporadic measures are effective in temporarily lowering urban temperatures, but they provide no long term solution to the UHI. UHI adaptation demands the incorporation of long term policy measures such as energy saving measure, energy saving measure with the object of alleviating global warming and long term infrastructure development scheme. So, adaptation of the UHI is not just a single hand process of application. In long term perspective the adaptation measures are much in common with global warming. From the urban planning perspective some common adaptation measures are: energy and resource savings in buildings, energy saving in the traffic system, restoration of green spaces and improvement of urban air flow. So, in long term perspective UHI adaptation measures must involve not only individual measures based on environmental technologies but also specific measures to improve infrastructures such as roads, rivers, parks, green spaces. Some mitigation measures demands extensive urban planning concern. For example creating wind paths for urban ventilation. It is long term process and has to deal with urban fabrication. Only comprehensive and systematic incorporation of the concept in urban planning scheme can give effective result.

4.3 Summary

In this chapter different UPP tools are described and tried to analyse their way of working. It is evidenced that most of UPP tools are effective to protect and reduce the emission from the transport sector. Some are purely comprehensive policy tools such as promoting urban density, TOD, TDM etc. These are the tools that demand integration and incorporation with the other fields of policy issues such as economic policy, environmental policy. On the other hand some regulative and operational policy tools are applicable in the sense to bring the effective result of other policies. These operation tools help and guide to get the optimum results from the mentioned comprehensive policy tools. To frame out all planning and policy tools two broad categories were followed: Emission control UPP tools and Effect based UPP tools. Considering the influence level of scale the problem of climate change and air pollution are integrated to frame out the tools. Climate change itself is a global problem. On the other hand Air pollution is primarily a local then a regional problem. In the level of integration the concern was given the general characteristics of these two problems. In the emission control level the common root causes behind their happenings are focused to frame out the common policy tools. On the other hand the at the impact level the global and local juxtaposition of the problems is considered.

Urban density, Urban form, urban design aspects, TOD, FAR and zoning are discussed under the land use strategy. Land use strategy is more important from the perspective of urban planning and policy tools. All tools not only help to reduce the problem of air pollution and climate change but also they have influence on the other urban systems. For example, increasing and maintaining urban density may help to reduce the emission effects at urban and regional scale. On the other hand this policy has some direct impacts on the other urban system such as resource density, employment density. It is evidenced that no single policy is effective to solve the problem. They may help to solve the problem in a narrow scale but from another perspective they can enhance the problem. In this chapter all of the issues tried to frame out. Travel demand and Urban livelihood development strategy was discussed separately under indirect emission control tools with land use strategy. On the other hand there are number of available direct tools that are applicable to control the emission. To frame out the direct emission control tools consideration is given to those that are interlinked with the total and comprehensive development process of an area. In relation with this consideration mitigation fee and emission density zoning were discussed. At the final stage of this chapter the effect based tools were identified. A common effect of climate change and Air pollution problem was discussed (in this case that is UHI) and the adaptation measures were then discussed.

In the following scheme (table4.12) all of the discussed tools are listed and how they work against the problem of air pollution and climate change are briefly worded to give an at a glance idea about the discussed issues. The inter-linkages and influences are also given in the same table.

Table 4.12: Comparative UPP tools against the Problem of Air pollution and Climate change

	Category of Planning and policy tools	Planning Tools and Policy	Major Linking Components with Air Pollution	Major linking components with climate change	Linkage with other policy tools
Emission Control Based planning and policy Tools	**Indirect Emission Control (IEC)**	**Land use Strategy**			
		a. Increasing and Maintaining Density	-Reduced VMT -Reduced Energy Consumption -Chance of concentrated Air pollution -Increased Micro local temperature and air pollution	-Reduced VMT -Reduced Energy Consumption -Risk of increasing climate Vulnerability	-Urban Spatial Form -Zoning -FAR -UHI
		b. Urban Spatial Form	-Effective transport Mobility -Changing Driving Behaviour	-Energy Efficient Transport Mobility	-Urban Density -Transit Oriented Development -Urban Design aspects
		c. Floor Area Ratio	-Facilitate TOD, help to reduce VMT -Help to promote not motorized development	-Facilitate TOD, help to reduce VMT -Help to promote not motorized development	-Density -TOD -Urban Design Aspects(Land use Mix,)
		d. Zoning	-Facilitate TOD, Transport Effective Development -Help to reduce VMT	-Facilitate TOD, Transport Effective Development -Help to reduce VMT	-TOD -Densities
		e. Urban Design aspects	-Increase walk ability -Reduce VMT	-Increase walk ability -Reduce VMT	-Urban Spatial Form -FAR TOD
		f. Transit Oriented Development	-Increase rider ship of transit -Reduce VMT of private vehicle -reduce fuel consumption	-Increase rider ship of transit -Reduce VMT of private vehicle -reduce fuel consumption	-Urban design aspects -Densities -FAR -Zoning -urban spatial form
		Travel Demand Management	-Reduced Transport use -Reduced private vehicle ownership	-Reduced Transport use -Reduced private vehicle ownership	-Urban design aspects -TOD
		Urban Livelihood Improvement Strategy	-Change energy consumption pattern	-Change energy consumption pattern	-Urban poverty eradication -Urban design aspects

Table 4.10: Comparative UPP tools against the Problem of Air pollution and Climate change

	Category of Planning and policy tools	**Planning Tools and Policy**	**Major Linking Components with Air Pollution**	**Major linking components with climate change**	**Linkage with other policy tools**
Emission Control Based planning and policy Tools	**Direct Emission Control (DEC)**	Mitigation Fee	-Discourage the adverse development	-Discourage the adverse development	-Comprehensive urban conservation planning
		Emission Density Zoning	-Restrict the emission by imposing limit	-Restrict the emission by imposing limit	-Land use planning and Zoning
Effect Based Planning and policy tools	**UHI Heat Island Mitigation**	Reduction of Anthropogenic heat	-reduce energy consumption, reduce emission, reduce the formation of Ozone and NOx	-reduce energy consumption and reduce emission	-urban energy policy
		Improvement of artificial surface Covers	-increase greening and reduce heat and formation of secondary pollutants	-improved carbon cycle	-building and urban design
		Improvement of Urban Structures	-integrity between natural and artificial environment, improved air quality	-improved built environment help to reduce energy consumption and emission of GHGs	-comprehensive urban planning

References

Introduction and Urban Density

1. Babcock R Lyndon, Jr., Niren L. Nagda, Edward J. Koval May (1975) Land-use Aspects of Air-Quality Management. *Science of the Total Environmen*t Volume 4, Issue 1, pp. 63-77

2. Batuad Alain (2002) Urban Planning and Air Quality. South Asia Urban Air Quality Management Briefing Note NO.6, UNDP/World Bank Energy Sector Management Assistant Programme (ESMAP)

3. Condon M. Patrik, Duncan Cavens and Nicole Miller (2009) Urban Planning Tools for Climate Change Mitigation. *Lincoln Institute of Land Policy*

4. Coutts Andrew M., Berineger Jason and Taper Nigel J. (2006) Impact of Increasing Urban Density on local Climate: Spatial and Temporal Variations in the Surface Energy Balance in Melbourn Australia. *Journal of Meteorology and Climatology*, vol 46, pp. 477-493

5. Dajania Jarir S., Tedd H. Jettb and P.Aarne Vesilindc (1977) Air pollution Control through Land-Use Planning. *Urban Systems* Volume 2, Issue 1, pp. 35-43

6. Dodman David (2009) Urban Density and Climate Change. Analytical Review of the Interaction between Urban Growth Trends and Environmental Changes, United Nation Population Fund (UNPF),

7. Ewing,R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D., McCann, B. and Goldberg, D. (2007) *Growing Cooler: The Evidence on Urban Development and Climate Change.* Chicago: Urban Land Institute

8. Glaeser Edward L, Kahn Mtthew (2008) The Greenness of Cities. Harvard Kennedy School / Taubman Center for State and Local Government. Policy Brief, March,2008 Retrieved from: http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers programs/centers/taubman/policybriefs/greencities_final.pdf

9. Gottdiener, M., Budd, L. (2005) *Key Concepts in Urban Studies*. London, Sage.

10. Jabareen, Y. (2006) Sustainable Urban Forms: Their Typologies, Models, and Concepts. *Journal of Planning Education and Research,* Vol 26, pp. 38-52.

11. Neuman M (2005) The Compact City Fallacy. *Journal of Planning Education and Research,* Vol 25, pp. 11-26

12. Newman, Peter W. G. and Kenworthy, Jeffrey R. (1989) Gasoline Consumption and Cities. *Journal of the American Planning Association*, vol 55, No1, pp.24 -37

13. Satterthwaite D (1999) The Key Issues and the Works Included' in Satterthwaite D (ed) *The Earthscan Reader in Sustainable Cities*, pp 3-21. London, Earthscan.

14. Steemers Koen (2002) Energy and the City: Density, Buildings and Transport. *Journal of Energy and building*, Vol 35, No 1,pp.3-14

15. Wendell Cox (2000) *How Urban Density Intensifies Traffic Congestion and Air Pollution.* Arizona Issue Analysis, Wendell Cox Consultancy.

Urban Spatial Form

1. Alonso, William (1964) *Location and Land Use*. Cambridge, MA: Harvard University Pres

2. Baldasano J, Soriano C, Boada L (1999) Emission Inventory for Greenhouse Gases in the City of Barcelona, 1987-1996, *Atmospheric Environment* Vol 3, pp. 3765-3775.

3. Bertaud, Alain, and Stephen Malpezzi (2001). Measuring the Costs and Benefits of Urban Land Use Regulation: A Simple Model with an Application to Malaysia. *Journal of Housing Economics* Vol:10, No 3,pp:393–418.

4. Bertuad Alain (2004) Spatial Organization of cities: deliberate outcome or unforeseen consequence. Working Paper, Institute of Urban and Regional Development, University of California at Berkeley

5. Borrego, C., Martins, H., Tchepel, O., Salmim, L., Monteiro, A. and Miranda, A.I. (2006) How Urban Structure can Affect City Sustainability from an Air Quality Perspective. *Environmental Modelling and Software* volume 21, pp.461-467

6. EEA: European Environment Agency (2000). Europe's Environment – The Dobris Assessment. Copenhagen.

7. EPA, 2001. Our Built and Natural Environments: A Technical review of the interactions between land use, transportation and environmental quality (EPA 231-R-01–002). Washington.

8. Kent J. H. and Mudford N. R. (1979) Motor vehicle emissions and fuel consumption modelling. *Transportation Research,* Vol 13A, pp 395-406.

9. Lyons T.J, Kenworthy R.J and Newman P.W.G (1990) Urban Structure and Air Pollution. *Atmospheric Environment volume* ,Vol 24B, No 1, pp 43-48

10. Muth, Richard F. (1969) *Cities and Housing*. Chicago: University of Chicago Press.

11. Simanaitis D. J. (1977) Emission test cycles around the world. *Automotive Engng*. Vol 85, No 8, pp 34-43.

12. USEPA (1984) User's guide to MOBILE3 (Mobile Source Emissions Model), EPA 460/3-84-002. U.S.E.P.A., Ann Arbor, Michigan.

FAR

1. Bertuad Alain (2004) Spatial Organization of Cities: Deliberate Outcome or Unforeseen Consequence. Working Paper, Institute of Urban and Regional Development, University of California at Berkeley

2. Kuzmyak Richard J., and Pratt Richard H. (2003), *Land Use and Site Design: Traveler Response to Transport System Changes*, Chapter 15, Transit Cooperative Research Program Report 95, Transportation Research Board (www.trb.org); Retrieved from: http://gulliver.trb.org/publications/tcrp/tcrp_rpt_95c15.pdf.

3. Litman Todd (2010) *Land Use Impacts on Trans port: How Land use Factors Affect Travel Behaviour*. Victoria transport policy Institute with Rowan Steele.

4. Los Angles Housing Department (2010), What are the Basics of Land Use and Planning Regulations, Retrieved on October, 2010 from : http://www.ci.la.ca.us/LAHD/curriculum/gettingfacts/planning/planconcepts.html

5. Portland (1995) *Parking Ratio Rule Checklist; Self-Enforcing Strategies*, City of Portland.

6. Sridhar kala Seetharam (2010) Impact of Land use Regulations: Evidence from India's cities. *Journal of urban studies,* vol 47,No7

Zoning

1. Nolon John R. (2007) Zoning Transportation and Climate Change. *New York zoning and law practice report*. Vol.8, No. 2

Urban Design Aspects

1. Cervero R, Duncan M. (2003). Walking, Bicycling, and Urban Landscapes: Evidence from the San Francisco Bay Area. *American Journal of Public Health,* Vol 93,No 9, pp.1478–1483.

2. Cervero Robert and Radisch Carolyn (1995) *Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods*. UC Transportation Center, UCTC 281 (www.uctc.net).

3. Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research D,* vol:2, No (3), 199–219.

4. Dill Jennifer (2005) *Measuring Network Connectivity for Bicycling and Walking*, School of Urban Studies and Planning, Portland State University.

5. Ewing, R., & Cervero R. (2001). Travel and the Built Environment: A synthesis. *Transportation Research Record,* No 1780, pp. 87–114. Retrieved on October,2010 from: http://depts.washington.edu/trac/concurrency/lit_review/trr1780.pdf

6. Frank Lawrence D, Stone Bian Jr, William Bachman (2000) Linking land use with Household Vehicle Eemissions in the Central Puget sound: methodological framework and findings *Transportation research Part D5* pp:173-199

7. Frank Lawrence, Sallis JF, Conway T, Chapman J, Saelens B, Bachman W (2006) Multiple Pathways from Land Use to Health: Walkability Associations with Active Transportation, Body Mass Index, and Air Quality. *Journal of the American Planning Association* Vol. 72 No. 1.

8. Frank, L.D., Pivo, G., (1995). Impacts of Mixed Use and Density on the Utilization of Three Modes of Travel: Single Occupant Vehicle, Transit, And Walking. Transportation Research Record, Washington, DC.

9. Frumkin H, Frank L, Jackson R. (2004). *Urban Sprawl and Public Health: Design, Planning, and Building for Healthy Communities*. Washington, DC: Island Press.

10. Handy Susan and Mokhtarian Patricia L. (2005) Which Comes First: The Neighborhood Or The Walking?, ACCESS 26, University of California Transportation Center (www.uctc.net), Spring 2005, pp. 16-21. Retrieved on September,2010 form : www.des.ucdavis.edu/faculty/handy/walking_or_neighborhood.pdf

11. Handy Susan, Paterson Robert G. and Butler Kent (2004) *Planning for Street Connectivity: Getting From Here to There*, Planning Advisory Service Report 515, American Planning Association
12. Kulash, W. (1990). Traditional Neighborhood Development: Will the Traffic Work? In: Proceedings of the Eleventh Annual Pedestrian Conference, Bellvue Washington.

13. LFC: Lawrence Frank & Company Inc, Mark Bradley and Keith Lawton Associates. (2005a). Travel Behavior, Emissions, & Land Use Correlation Analysis in the Central Puget Sound. Prepared for the Washington State Department of Transportation, Olympia WA. Report no. WA-RD 625.1.

14. LFC:Lawrence Frank & Company (2008) *Reducing Global Warming and Air Pollution: The Role of Green Development in California,* prepared for Environmental Defence Fund.

15. Marshall Julian D, Brauer Michael, and D. Frank Lawrence (2009), Healthy Neighborhoods: Walkability and Air Pollution, *Environ Health Perspect* , Vol 117,pp1752–1759.

16. McPherson, G.E. (1994). *Cooling Urban Heat Islands with Sustainable Landscapes. In: Platt, R., Rowntree, R., Muick, P.,* The Ecological City. University of Massachusetts Press, Amherst, MA.

17. Moudon Anne Vernez (1996) *Effects of Site Design on Pedestrian Travel in Mixed Use, Medium-Density Environments*, Washington State Transportation Center, Document WA-RD 432.1, Retrieved form: (www.wsdot.wa.gov/ppsc/research/onepages/WA-RD4321.htm).

18. Moudon AV, Lee C, Cheadle AD, Garvin C, Johnson D, Schmid TL, Weathers RD, and Lin L (2006). Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights. *Journal of Physical Activity and Health* Vol 3, Suppl 1, pp. S99-S117

19. PBQD (1994), *Building Orientation;* Supplement to *The Pedestrian Environment*, 1000 Friends of Oregon (www.friends.org).

20. Sallis Dr. James, Saelens Dr. Brian, McCann Consulting, GeoStats LLC, and Washbrook Kevin (2005). *A Study of Land Use, Transportation, Air Quality and Health in King County, WA*. Prepared for the King County Office of Regional Transportation Planning, Lawrence Frank and Company (LFC) Inc.

21. USEPA (2004), *Improving Air Quality Through Land Use Activities - EPA Guidance*, EPA420-R-01-001, Office of Transportation and Air Quality, USEPA (www.epa.gov); Retrieved on October, 2010 from : www.epa.gov/OMS/stateresources/policy/transp/landuse/r01001.pdf.

22. VTPI: Victoria Transport Policy Institute (2005) *Land Use Impacts on Transport*, Online TDM Encyclopedia. Retrieved on September, 2010 from http://www.vtpi.org/tdm/tdm20.htm

TOD

1. Calgory City Council (2004) *Transit Oriented Development, Best Practices Handbook,* The City of Calgary, Land Use Planning and Policy

2. Calthorpe, Peter (1990) Transit-Oriented Development Design Guidelines for the County of Sacramento, Peter Calthorpe Associates (p. 5).

3. Cervero, R. and Duncan, M. (2002) Benefits of proximity to rail on housing markets: experiences in Santa Clara County, Journal of Public Transportation, Vol 5, pp. 1–18.

4. Cervero, Roberto (2004), *Transit Oriented Development In United States: Experience Challenges, And Prospects* United States, federal transit administration, transit cooperative research programme, Retrieved from: http://books.google.com/books?id=a6__pNpM44MC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

5. CO2 Emission Calculator, Calculated on October, 2010. Available at: http://www.transportdirect.info/Web2/JourneyPlanning/JourneyEmissionsCompare.aspx

6. Davis todd and Hale Minica (2007) Public Transportation's Contribution to Greenhouse Gas Reduction, SAIC: From Energy to Solutions

7. Nelson Dick, Niles John, Aharon Hibshoosh (2001), *A New Planning Template for Transit Oriented Development*, Mineta Transport Institute College of Business, San Josè state University.

8. Statewide Transit Oriented Development Study (2002) *Factors for Success in California*,Final Report.

9. TCRP:Transit Cooperative Research Programme (2004) *Transit-oriented development in the United States: experiences, challenges, and prospects*. Report No. 102, TCRP, Washington, DC. Retrieved on October,2010 from: *trb.org/publications/tcrp/tcrp_rpt_**102**.pdf*

TDM

1. Farguson Erik ,(1998) Travel Demand Management, *Journal of planning literature* vol 13,pp100-126. Retrieved from: http://jpl.sagepub.com/content/13/1/100.citation

2. Grant Michael, Lissa Ecola and Wendy Messenger— ICF International (2007) Transportation Demand Management Programs as an Emissions Reduction Strategy: New Challenges and Opportunities

3. NEIAPETD: National Emissions Inventory Air Pollutant Emissions Trends Data, (2002) http://www.epa.gov/ttn/chief/trends/index.html#tables.

4. World Bank (1996), The role of World Bank in Transport Sector.

Livelihood Improvement

1. Chambers R & Conway G, (1992) *Sustainable rural livelihoods: practical concepts for the 21st century*, IDS discussion paper No 296, IDS: Sussex

2. Meikle Sheilah, Ramasut Tamsin, Wlaker Julian (2001): *Sustainable Urban Livelihoods:Concepts and Implications for Policy,*Working Paper No:112.

3. Suybros Nhean, Dalina Moeng, Kemly Ouch and Chumnith Sam, (Unknown) THE IMPACT OF BIOMASS FUEL CONSUMPTION ON AIR QUALITY AND HUMAN HEALTH: A case study at Prey Chisak and Prey Pring Tboung village, Choam Chau Commune, Dangkao District, Phnom Penh, Cambodia, Department of Environmental Science, Royal University of Phnom Penh

4. UNDP (A), (1997) *Productive Employment And Poverty Eradication. How Can Livelihoods be More Sustainable*, UNDP

Direct emission control tools

1. Frank, J., and P. Downing. (1988). Patterns of impact fees use. In Development impact fee, edited by A. C. Nelson, 3-21. Washington, DC: Planners.

2. Nicholas James C, Julian Juergensmeyer Conrad (2003), Market Based Approach to Environmental preservation:To environmental mitigation fees and beyond, *Natural resource Journal,Vol:43 pp:837-864*

3. Norman F.Kron Jr, Alan S. Cohen and Linda M. Mele (1978) *Emission Density Zoning Guidebook: A Technical Guide to Maintaining Air Quality Standards through Land-Use-Based Emission Limits,* Environmental Peotection Agency, US.

4. Wikipedia (2010) Linkage and Mitigation Fee, Retrieved on October, 2010 from: http://en.wikipedia.org/wiki/Mitigation_fee

Urban Heat Island

1. Arnfield, A. J. (2003) Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the urban heat island, *International Journal of Climatology,* 23, pp. 1–26.

2. Che-Ani A.I, Shahmohamadi P., Sairi A., Mohd-Nor M.F.I, Zain M.F.M,Surat M. (2009) Mitigation of Heat Island Effect: Some points without altering existing city Planning, *European Journal of Scientific Research*, Vol:35,No:2, pp: 204-216

3. Crutzen, P. J. (2004). New Directions: The growing urban heat and pollution island effect-impact on chemistry and climate. *Atmospheric Environment* 38: 3539–3540.

4. Gorsevski Virginia, Taha Haider, Quattrochi Dale, Luvall Jeff,(#) Air pollution Prevention through urban heat island mitigation An update on urban heat island pilot project.

5. IPCC:Intergovernmental Panel on Climate Change (2001) *Working Group I Third Assessment Report,* Cambridge, UK, Cambridge University Press.

6. Lee D O. (1993) Climate change and air quality in London. *Geography* No.78,pp77 - 79

7. NRC:National Research Council,Committee on Tropospheric Ozone Formation and Measurement, (1991) *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Academy Press, Washington, DC.

8. Oke T.R.(1987). *Boundary Layer Climates,* Second Edition, London: Methuen and Co., 435.

9. Oke, T.R. (1997) Urban Climates and Global Change. In Perry A and Thompson R eds *Applied Climatology: Principles* and Practices, pp. 273–287. London: Routledge.

10. Rosenzweig, C.E., Solecki, W.D. (Eds.), (2001) Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region, Columbia Earth Institute, New York.

11. Stedman J R, (2004) The Predicted Number Of Air Pollution Related Deaths in The UK during the August 2003 Heatwave. *Atmospheric Environment,* vol 38, pp. 1083-1085

12. Taha, H., D. Sailor, and H. Akbari. (1992). High-Albedo Materials for Reducing Building Cooling Energy Use. *Lawrence Berkeley National Laboratory Report* No. 31721 UC-350: 71

13. UNFPA: United Nations Population Fund (1999). The State of World Population 1999. New York: UNFPA.

14. Vooget James A (2004), *Urban Heat Island: Hotter Cities*, Retrieved on November ,2010 from http://www.actionbioscience.org/environment/voogt.html

15. Wilby Robert L, (2007) Constructing climate change scenarios of urban heat island intensity and air quality. *Environmental and Planning B: planning and design*, vol 35, pp 902-919.

16. World Meteorological Organization. (1984). Urban Climatology and its Applications with Special Regard to Tropical Areas. *Proceedings of the Technical Conference Organized by the World Meteorological Organization*, Mexico, 26-30 November 1984 (WMO-No. 652): 534.

17. Yamamoto Yoshika, (2006) Measure To Mitigate Urban Heat Island. *Science and Technology Trend,* Quarterly Review no: 18

Chapter-V

Developing Integrated Urban Planning and Policy Framework

Chapter V
Developing an Integrated Urban Planning and Policy Framework

Key Words: Urban Planning and Policy (UPP) tools, Urban Systems, Urban Growth, Urban Development Compensation

In chapter 4 different UPP tools are framed out, compared and analysed from different point of views against the problem of air pollution and climate change. In this chapter integrating the all analytical findings of the different UPP tools a policy framework will be developed.

It is already analysed the way of working of different tools against the problem of air pollution and climate change. To frame out those tools the focus was given to the common influence domain of the two problems. The tools were framed according their effectiveness against the addressed problems. Within the limited extension of the study it is not wise to say that all tools are listed and framed. Instead, this study can give a path where other potential planning and policy tools can incorporate and adopt against the problem of climate change and air pollution. The developed framework of the planning and policy tools is that attempt to give the platform to adopt and incorporate other tools against the problem. This frame work will act as an umbrella. On the other hand based on problem and its relevant magnitude, extension and context all or some of the listed tools may be applicable. The application suitability differs according to the context. This demands another level of study. The most important thing of at this stage of the study is to develop the integrated framework which can work as a solid base for the application of all listed tools. In the following the development procedures, basic features and component and logical relation are discussed of this framework.

5.1 Scale Fixation and State of Art Analysis

Climate change and air pollution are problems that differ at taking place levels and scale. Air pollution is primarily a local then a regional problem due to the transboundary transport of the pollutant. On the other hand the climate change is a problem of global phenomenon. In chapter-3 it is already explored that how these two problems are influencing one another from different levels. In policy framing the level of interaction of these two problems and the state of art have to analyse. Based on this state of art analysis the urban and environment system have to explain in term of the problem's magnitude and extension. Different magnitudes and level of extension of the problem help to frame out the emergency policy response. In the developed frame work the application period of each tool is important to get the effective result. After that based on the magnitude and extension of the problem the two branches of the problems have to identify one is the Source and another one is the impact. How do these two things are juxtaposed at urban scale have to analyse. From the analysis of different tools the juxtaposition of their two branches of air pollution and climate change problem can be categorized in three broad titles. Their integration works on these three basic sectors of an urban area. They are: Urban system, Urban Growth and Urban Development. In the next these three categories will be explained and different tools will be fitted to each category to develop the UPP framework.

5.2 Urban System Optimisation

System is a group of interacting, interrelated and or interdependent elements forming a complex whole. An urban area is a composition of number of complex systems (i.e. transportation system, housing and neighbourhood system, urban eco-system etc). The urban systems are not rigid concepts. It means it is not possible to identify the fix components of a system in a certain context. For example in different urban context the component of transportation system differs. In an uncertain situation the important thing is to judge the system optimisation with refer to certain object. The level of optimisation also varies according the existing situation, demand and future needs. In terms of air pollution and climate change problem this system optimisation can give an improved solution. So in the policy framing the system optimisation should get the prime focus. How different systems are in deficit condition have to analyse in the policy framing stage. Different tools are then can be fitted under different strategies to increase the optimisation and solve the problem.

On the other hand different urban systems are continuously changing due to different driving forces. Bai (2005) indicates two types of drives that are changing the different urban systems. One is direct driving forces and another one is indirect driving forces. Among indirect driving forces the author noted globalisation, technological change, political shifts (including institutional and legal framework changes) and demographic shits. As direct driving forces the authors noted the changes in land use, use rights and structures. Again this driving forces works on urban system in different ways based on the economical position (i.e developing world cities and developed word cities) of the particular cities. For example the trend of globalisation in developed cities is different than the cities of developing countries. In a general policy framework this changing trend of urban systems and the influences of different driving forces have to consider. The available policy tools that are in practice have to apply under a common framework and to get the optimum output.

In chapter-4 there were listed numbers of UPP tools. Some of those tools work to increase the optimisation of certain system directly. From air pollution and climate change perspective this system optimisation should get the priority in policy framing. For example in a certain context for a certain urban area the TOD can be effective tools to bring the total optimisation of transport system. On the other hand it also helps to reduce and control the emission problem. The message is that the urban system optimisation should have to bring in mind first in certain context with certain system capability. System capability and lacking have to explore with the changing trend due to different driving (direct and indirect) forces. Then the issue of air pollution and emission control have to incorporate with the system optimisation. So, UPP tools are not a directive measures to solve a problem of air pollution and climate change. Rather in policy frame working the issue of climate change and air pollution should be incorporated as associative issue. Urban system optimisation is one of the core branches of the proposed policy frame work. Among the listed UPP tools urban design aspects, TDM, TOD, Anthropogenic heat reduction, artificial surface coverage and structural improvement are categorized under the urban system optimisation in the proposed frame work. TDM and TOD are two planning and policy tools that are applied to optimise the urban transport system. The application of these two tools should be focus to the optimisation of the urban transport system. With the issue of this optimisation the issue of air pollution and climate change should be incorporated in the formation of strategy and policy. The state of the art of the air pollution and global influence of climate change in relation with these two tools has to consider from the particular city perspective during the forming particular strategy.

Some Urban design aspects as UPP tools are discussed that also help to optimise the operational output of the different urban system. For example the well connected road network helps to reduce the VMT and VHT that alternatively reduce the emission problem and energy consumption. So the basic is the maximization and optimisation of the operational out put of the urban road network system. Again neighbourhood and urban environment with improvement walk ability facility increase the pedestrian tips that also help to reduce the air pollution and emission problem. Similarly land use mix also helps to improve and optimise the neighbourhood environment by promoting walk able environment. The tools that are discussed to mitigate UHI are also primarily work to optimise the urban comfort system.

Another important thing should be bear in mind in this policy frame work that is the interrelationship among the all tools. One tool is necessary and applicable for the smoothness of the other tool. For example some of the urban design aspects such as increased walk ability, well connected road network, land use mix also influence the application of TDM and TOD. Finally it is said that the different urban tools that have already framed have to implement at the city level under a comprehensive planning framework. It is not a matter to put and impose those separately. Urban system optimisation is one of the components of this comprehensive planning framework that help to develop a proper planning and policy integrating all tools for a certain city.

5.3 Urban Growth Management

In the develop policy framework another important consideration is urban growth. The phenomenon of urban growth is important for the better management of an urban area. Not only for urban management but also for sustainable environment and resource consumption urban growth is now an issue of concern. Urban growth are usually expressed in two ways one in physical growth and another one is population growth. From the air pollution and climate change perspective the physical growth of urban area is matter of main focus as the physical growth of urban area influence the energy consumption pattern and emission problem of the urban area. So in case of developing the policy framework the urban growth is considered as another main component under which the listed UPP tools can be framed. Among the listed tools Increasing and Managing Urban density, Urban Spatial form, FAR, Zoning and EDZ are directly and indirectly related with the urban growth management. It is already explored that how the different tools act against the problems of air pollution and climate change.

Again urban growth is influenced by number of driving forces. In different development context those driving forces also differ. In some case demographic pressure is the prime driving force behind urban growth. In some cases the economic growth, social and political issues act as prime cause behind the urban growth. Some spatial utilities also help to promote urban growth such as land price, physical suitability of the land, road accessibility with other major areas etc. Urban growth itself is an issue in urban management and development issue. All of those are out of scope of discussion. The most important thing from this study point of view is that the consideration of urban growth management in case of applying the listed tools. For example increasing urban densities is a positive and in some cases negative forces for air pollution and emission problem. So, in case of application of this tool in core policy level the main growth strategy have to be considered in relation with emission problem of the city.

Urban spatial form is another issue that is also related with the urban growth management. In a new development it is possible to give a form of the developed urban area. On the other hand in case of already built city that was developed in more natural way than promoted guidance is really matter of concern in terms of urban form. It is rare to give a polycentric city to monocentric city shape or vice versa. In relation with this problem the most important thing at policy framing stage is to consider the characteristics of these urban forms and their influence level in urban growth management

FAR, Zoning, EDZ are basically tools that stimulate and restrict the rise and dead of others. It is explore that how increased FAR helps in the development of TOD and how it helps to promote mix use. On the other hand Zoning and EDZ work almost in same way. Both specify the particular uses with particular limitation. Though these tools help to the development and implementation of other tools, here it is considered under the urban growth management component as they be able to restrict the development and manage the growth of urban area. Finally the listed tools are framed under the urban growth and management component to develop a comprehensive urban policy for a city.

5.4 Development Compensation

This is another component of developed policy framework. Urban area can’t think without development. All developments are not goods considering the resultant effects. Some of the effects are unavoidable in the process of development. Again some effects are avoidable. Avoidable development works should be compensated if they taken place in the space. From this consideration this component is added in the developed policy framework. Development is usually evil considered from environmental point of view. To compensate this bad effect in terms of finance mitigation fee is considered as an UPP tools. Mitigation fee itself demands the comprehensive conservation planning. This is way in the study mitigation has considered as an UPP tool rather as financial tool. But in the application level it is not a wise thing to apply in a separate way. From this realization it is considered as under the development compensation component of the developed policy framework. The idea is to give a core basic of the tools to apply in the urban area with the object to solve the problem of air pollution and emission at urban scale.

5.5 Summary:

The listed tools are not a panacea to solve the problem of air pollution and climate change. The consideration of all UPP tools under compressive planning framework will help to ease the problem and it will be possible to get the maximum benefit from the application of those tools. In the following the developed planning frame work is given in a figure.

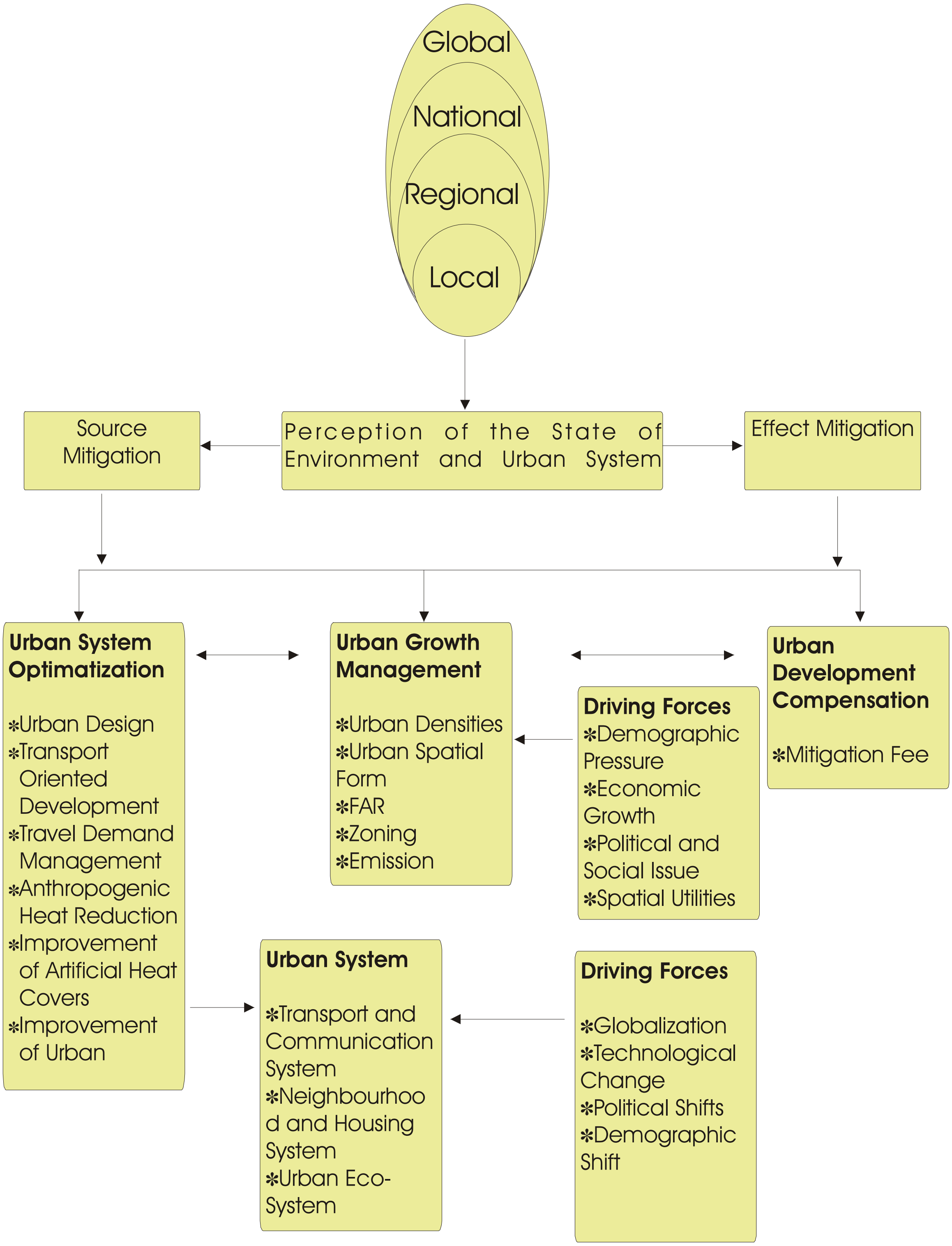


Figure 5.1: Model Policy Framework of UPP tools

References:

1. Bai Xuemei, Balk Deborah, Braga Tania, Douglas Ian, Elmqvist Thomas, Rees William, Satterthwaite David, Songsore Jacob, Zlotnik Hania (2005) Urban System. In: Hassan Rashid M., Scholes Robert, Ash Neville (2005) *Ecosystems and human well being: current state and trends : findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment* Island Press, New York. Retrieved from: http://books.google.com/books?id=UFVmiSAr-okC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Chapter-VI

Application Context Analysis of Urban Planning and Policy Tools with Reference of Policy Framework: The Case Study of Dhaka

Chapter VI
Application Context Analysis of Urban Planning and Policy Tools with Reference of Policy Framework: The Case Study of Dhaka

Key Words: UHI, Building Delivery System, Building Orientation, Drainage System, Wind paths

This chapter deals with the analysis of the application context of the developed framework. Within limited timeframe of the study only one impact component of the climate change and air pollution was considered to depict the situation. It is already explored that climate change and air pollution are interacting at city level through the formation of UHI. The phenomenon of the UHI in case of Dhaka (Capital City of Bangladesh) will be explored here. In which way the different listed tools can be applied to adapt the problem of UHI under which policy framework will be explored here taking the case of Dhaka.

6.1 Problem of UHI at Dhaka (level of scale exploration)

Dhaka is the capital city of Bangladesh. Dhaka is facing number of problems. Among those problems one of them is Air Pollution. In the winter of 1996-97, air pollution of Dhaka city became the severest when lead in the air was reported higher than in the atmosphere of any other place of the world (Ahmed, 1997). After that some policy initiative eased the situation. Fixation of national ambient air quality standard, CNG run vehicle and ban on two stock diesel engines are some mentionable policy measures. Instead of all measures still air pollution exists as a city problem due to the high concentrations of some of the air pollutants. In the study of Begum and Ahmed (2010) some pollutants concentrations were revealed. The study found that for some pollutants the situation is better then the period of 2000-2001 but still they are exceeding the national standard of air quality. In the following the different air pollutant concentration are presented to compare with national standard as well as with WHO standard.

Table 6.1: Ambient Air Quality of Dhaka City

Name of the Particulates	Pollutant's Concentration	Bangladesh Standard	WHO standard
CarbonMonoOxide(CO)	5027.2* µg/m^3	10000 µg/m3 (8-hour average)	N/A
NO_x	331* µg/m^3	100 µg/m3 (Annual)	40 µg/m3 annual mean 200 µg/m3 1-hour mean
SO_2	N/A	365 µg/m3 (24-hour average)	20 µg/m3 24-hour mean 500 µg/m3 10-minute mean
PM_{10}	310* µg/m^3	150 µg/m3 (24-hour average)	20µg/m^3 annual mean 50 µg/m^3 24 hours mean
CO_2	500 ppm	N/A	N/A

*Average of 5 Stations (Mohakhali, Farmgate, Mogbazar, Sonargoan, Sciencelab) is calculated and 24 hour mean is put here.

From the table it is evidenced that the concentration of PM_{10}, NOx are higher than the Bangladesh standard and WHO standard. On the other hand the concentration of CO_2, O_3, soot and particles can change the micro temperature. In chapter-3 it has been presented that they have both heating and cooling effects at micro scale. The air pollution problem in case of Dhaka is acting as extra heating effect in urban area. With is micro scale problem there is added the issue of global warming. Dhaka is the one of the most vulnerabilities cities due to the global warming (effect of climate change)

Climate change will affect Dhaka primarily in two ways: through floods/ drainage congestion and through heat stress. The melting of glaciers and snow in the Himalaya and increasing rainfall will lead to more frequent flooding in Bangladesh. The water logging and drainage congestion due to river floods and excessive rainfall during the monsoon are already causing very serious damage. Furthermore, Dhaka may also face "heat island" problems because temperatures in the city are a few degrees higher than in the surrounding areas. Indeed, vehicle exhaust emissions, industrial activity and increasing use of air conditioning are contributing to heat (Alam and Rabbani, 2007). Box 6.1 depicts the UHI severity in case of Dhaka in a conference.

BOX 6.1: Problem of UHI in Dhaka

Recently the BRAC Development Institute in partnership with The University of Manchester held a conference on Climate Change and Urban Poverty where the issue of climate change and its affects on urban centres was discussed. At the conference Dr. Caroline Moser, Director, Global Urban Research Centre at the University of Manchester presented a paper titled, 'Towards a Pro-Poor adaptation to Climate Change in the Urban Centres'.

The paper raised some major issues and set them in the urban centres of low and middle income countries. A topic which should be of prime importance to the 15 million people living in Dhaka. Some of the likely impacts of climate change include, an increase in heat waves, warm spells, tropical cyclones, drought, rainfall and sea levels. And in urban areas such as Dhaka, the results could be catastrophic. With rising temperatures in urban settings there is an increased risk of cities becoming urban heat islands.

David Hume, a professor of Development Studies at the University of Manchester says, "The problems with urban heat islands are multi faceted. But if one was to look at the greatest effect it has on the poor urban population I would have to say it would be ventilation." The ventilation in urban slums is notoriously insufficient, and with rising temperatures there is an increased risk of respiratory diseases. Hume goes on to say, "the effects of climate change on urban areas includes more intensive rainfall and climate variability. Issues which are tricky to deal with, especially in least developed countries (LDC)."

Source: The daily Star Weekend Magazine,Volume: 8Issue56,February 6,2009

Moreover, it is evidenced that the summer is getting bigger (5-6 months long instead of 3 months in 30 years back). In some hot days the temperature goes up to 40° C in the city and surrounding areas. Winter has become small but in some years it becomes very cold. In such a situation the listed tools under the developed policy framework will be analysed in the context of Dhaka. The object will be analysed the different policy aspects to adapt the heat island effect in Dhaka city.

6.2. Developed Policy Frame work and Context of Dhaka City to Adapt UHI

In the developed policy frame work there are addressed number of tools that can be applied to solve the problem under the urban system optimisation component. Here the logic of this framework will be discussed by disclosing a real context of Dhaka city. In chapter 4 there were listed number of tools to adapt the problem of UHI. In broad strategy level the tools were indicated as 1. Anthropogenic heat reduction 2. Improvement of artificial surface coverage 3. Improvement of Urban Structures. It was also explored that operational scale of each of the tool. In case of anthropogenic heat reduction the most of the tools' operational scale is building. Most of the anthropogenic heat reduction tools are workable in the building in urban area. Now if it is carefully explored that how building goes with a broad policy framework, it is possible to analyse the developed framework. In this case it is logical to say that in an urban area the development of the building goes with the urban housing delivery system. How urban housing delivery system in broad policy level and its optimisation with the incorporation of those tools will be explained in the following. It is also mentionable that here only two urban systems will be explored in respect of Dhaka to justify that how the developed policy frame work can work to apply the framed tools. The tools under artificial surface coverage are also applicable in building scale as well as city scale. On the other hand structural improvement is largely dependent on the city scale. The application of different tools under structural improvement strategy differs according the context and scale and dimension of the problem at city scale. Here the issues of broad policy framework in respect of different urban system of Dhaka will be explored and the way to incorporate the policy of those tools in case of applying at city level will be mentioned.

6.2.1 Housing Delivery System

Housing is a big issue for the Dhaka. Dhaka is facing severe housing shortage. With an estimated population of about 13 million, Dhaka now suffers from severe backlog of housing provisions for middle and low income population. As city is in severe scarcity of housing the future provision of housing in the city will obviously be a natural as well as market demand. Islam and Salma (2008) in a study projected a figure of 4.45 million of housing units as the demand of Dhaka city by 2025. This huge housing demand is projected for three categories of people. In the table 6.2 the study findings are given. This housing demand will be met to the peoples through a housing delivery system. In the present housing delivery of Dhaka is divided in two broad categories. Houses delivered by public sector and houses delivered by private sector. In the figure 6.1 this housing delivery system is shown. At present system private sector is providing 93% and public sector is providing rest 7% of the total housing demand of Dhaka city. Private sector is again divided formal sector and informal sector. Formal sector is managing by individuals, private developers and cooperative housing while informal sector is managing by illegal ways and by individuals. So, it is evidenced that the total housing delivery system is composed by the group of people with different composition of interests in terms of their final achievement. Now the question is how the application of different tools of UHI mitigation at building level is related with building delivery system and what policies and strategies should be considered to apply those tools. In the next discussion it will be tried to explain with some directions for future endeavours.

Table 6.2: Projected and Proposed delivery of Dwelling Units (2008-2025)

Phase	Period	No of Dwelling Units to be Delivered			Total
		Low Income Group	Mid Income Group	High Income Group	
Phase I	2008-2013	.82(41)	1.10 (55)	.08 (4)	2.00 (100)
Phase II	2013-2018	.57(39.31)	.80 (55.17)	.08(5.52)	1.45 (100)
Phase II	2018-2025	.42(42)	.50 (50)	.08(8)	1.00 (100)
Total		1.81(40.67)	2.40 (53.93)	.24(5.39)	4.45 (100)

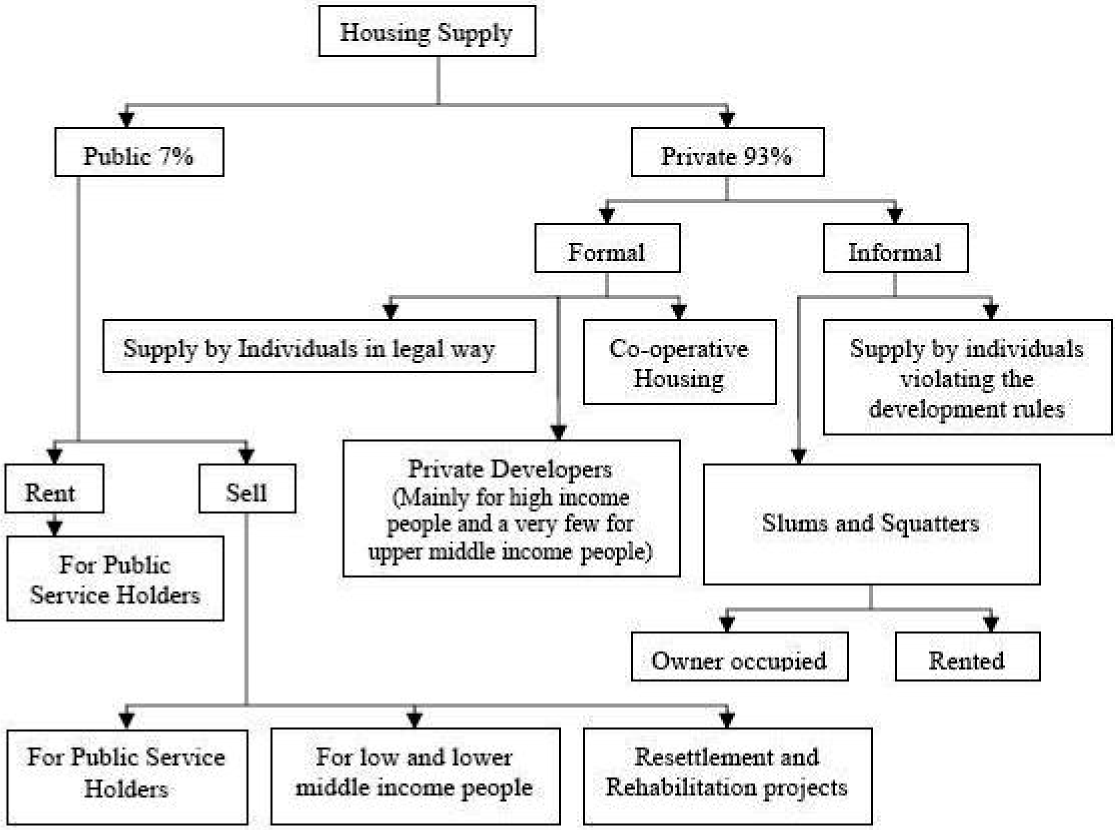


Figure 6.1: Housing Delivery System of Dhaka (Source: BBS (2001) Household Income and Expenditure Survey

6.2.2 Housing Delivery System of Dhaka and Application of Urban Heat Island Adaptation Tools

From the housing delivery system is evidenced that the system is operating by number of different interest groups. On the other hand to adapt the UHI the application of different tools will have to be applied in a whole and in comprehensive way. Some of the tools that have already addressed such as greening the roofs, Improvement in the reflectivity of walls and roofing materials, use of photovoltaic energy, use of insulation and thermo shield materials at building level needs to integrate with building delivery system under a policy framework. To adapt the heat island effect there is no alternative of adopting these techniques at city scale and building level. By imposing Regulation and encouraging individual initiatives it is almost impossible to apply such type of techniques at building level and city scale. Instead, under a proper policy framework the implementation of those tolls will be easy. Some issues are addressed here by addressing the question first and later by explaining the possible solution.

Why unique regulation is not suitable to impose those tools?

It is seen that in housing delivery system there is involved number of interest groups with different motives. For example the private housing companies have a fixed and concrete motive to do profit by doing business. So there target is to bring different products for different target groups with different profit level. As a result of this varied and market oriented objectives they are not likely to response any regulation that falls them in financial burden for certain products. On the other hand individual and cooperative housing have object to get the place for his/her/ their living. They are not so accustomed with environment friendly provision at building level. Moreover it is a matter of extra financing. In informal sector this is not an issue as they make their house in temporary structure. On the other hand public sector housing will be able to do this only if govt. be able to realize to do it. So this is a block process to impose this type of tools to follow at building level.

So what to do?

As this is problem at building level, the solution also exists at this level with the involved groups. The solution will only come through equitable policy framework and by modifying the building delivery system. In the following some policy recommendations are given to implement these tools at individual building in city level.

a. First of all govt have to work for the new housing scheme and projected housing in Dhaka city. It is evidenced the housing market is dominated by the private developers in Dhaka city. Their domination is much bigger than the Govt. intervention in housing sector of Dhaka. So in the projected level Govt have to work out how much contribution will they keep in housing sector to meet the total demand. Market level interaction by the government will ensure the affordable housing for the poor people with environmental technologies. Moreover equal market share or contribution will help govt to lead the implementation of something new.

b. To impose those tools government can give subsidy to different interest groups that are contributing to the housing delivery. This subsidy should provide base on market share and motive of housing production. Climate fund can be used in this purpose.

c. Government can allow some development incentives in terms of allowing extra FAR for the provision of those techniques in individual buildings. But this should comply with existing building construction rules and regulations. It should be carefully offer to avoid any ambiguities with existing building construction rules and regulations.

6.2.3 Urban Water bodies and Building Orientation to Adapt the UHI

Dhaka is a city which is surrounded by number of rivers (Map-6.1) and canals. The position and location of these rivers are positive forces for Dhaka city to adapt the problems of UHI. The implementation of adaptation scheme of UHI is not a matter to implement separately. It should be incorporate in the comprehensive physical planning programme for Dhaka city. Dhaka has already developed its Detail Area Plan (DAP) for the whole city. Unfortunately any physical provision and development of infrastructure for the adaptation of UHI such as creation of city wide wind path is not recommended. The settlement of the Dhaka is started to develop from the southern bank of Buriganga River. Creating wind paths from the river by altering the orientation of the building is a much possible work for Dhaka city due to its physical location. In present development context it is quite impossible to adopt such a massive programme. Some old and new development pattern along the river ways will clear the matter. In the planning document there is no such provision or thing about the development pattern of the area along the river. In a comprehensive development plan, such as DAP the incorporation of this type of provision can help to implement this type of tools to adapt the UHI. To do this the wind paths and seasonal variation of wind speed along the rivers have to study carefully. Based on the study findings the alignment and building orientation along the river has to fix to create the wind paths to city centre. The development of new area along the river is not considered the relation of building orientation in creation of wind path to existing and future UHI. In Figure 6.2 the layout plan and existing natural location of the newly developed city at the eastern part of Dhaka is shown to show the lacking policy to UHI. Purbachal is a going to be a new satellite city of Dhaka. In near future when it will get the shape of full development the UHI become a problem for built up area. The city is surrounded by two rivers named Balu River to its east side and Shithalakha River to its west side. In the figure only the part of its lay out plan is shown here to give an idea about the lack of policy in term of building orientation and development.

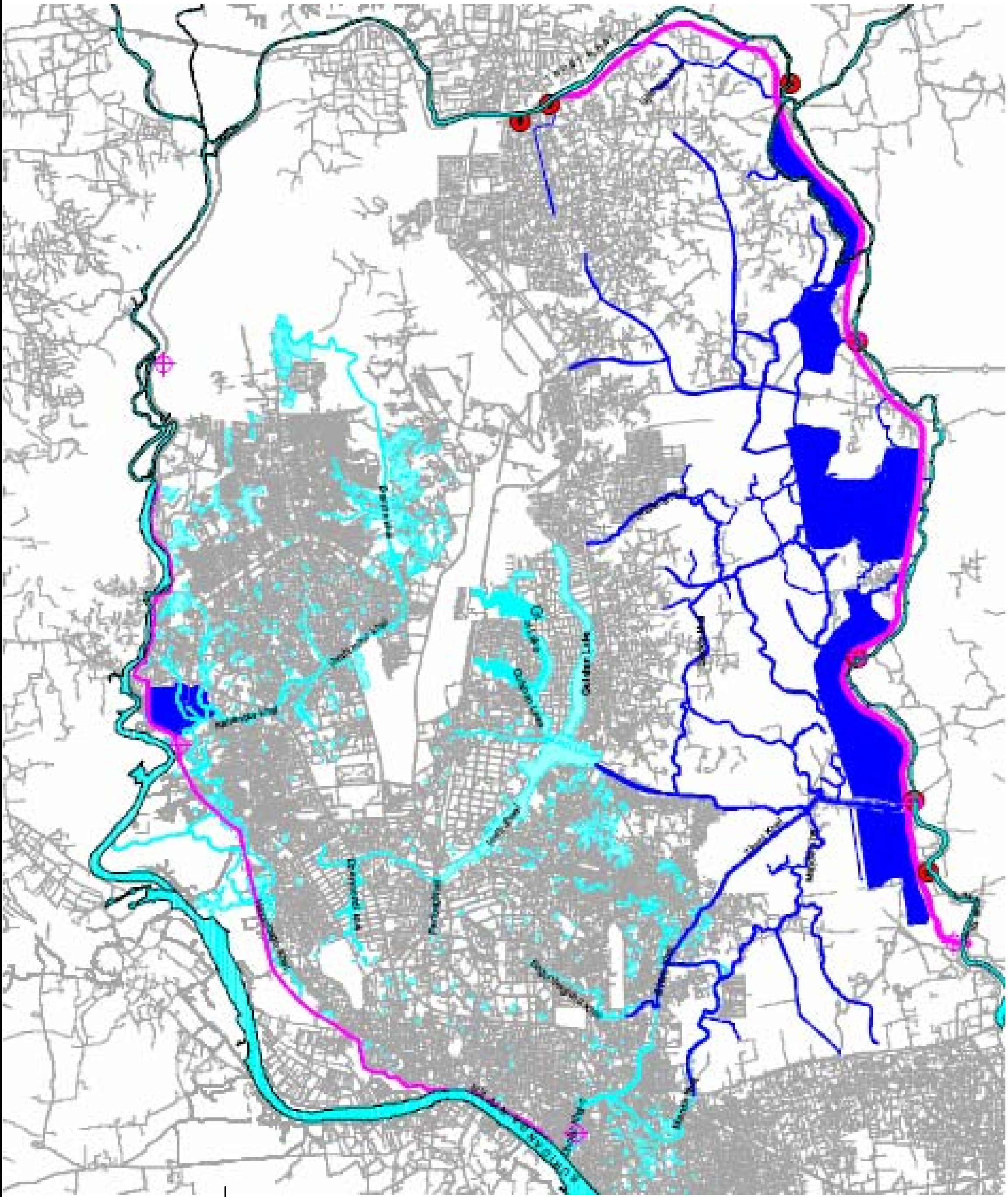


Figure 6.2: *Rivers and Canals of Dhaka (Drainage System)*
Source: *Detail Area Plan, Report of Group:C*

Figure 6.3: Water And free air circulation path along the river

Figure 6.4:Building Orientaion along the River (East-West Direction)In proposed layout plan of new city Purbachal, (At Eastern Fringe,Dhaka)

In present development context of Dhaka, some policy measures are given to implement the wind paths tool as a way to adapt the UHI:

a. Rivers and canals are the main features of the drainage system of Dhaka (figure 6.2). As a part of drainage system improvement some canals are presently excavating. Most of the canals were encroached by the people. In this situation in the new development scheme, with the drainage system improvement the issue of wind paths creation can be incorporated.

b. There should have some clear indication and study about the winds paths and seasonal directs along the river and river side development.

c. River side redevelopment scheme should consider the creation of winds paths to city centre.

6.3 Summary

Finally, the message is that the provision and implementation of those tools should not be applied separately. They all should be applied under a broad policy framework. The application of those tools is a subject of interest that how they will influence the individual urban systems. It can’t be said that the developed policy framework is universal and can applicable in any situation. Instead this policy UPP framework and tools will work as an umbrella that can be use to solve the problems against the integrated impact of climate change and air pollution.

References:

1. Ahmed N. (1997), "Air Pollution in Dhaka City," Key Note Speech at ChE Division of IEB, May, 1997.

2. Alam Mozaharul and Rabbani Golam M.D (2007). Vulnerabilities and Responses to Climate change for Dhaka, *Environment and Urbannization.* Online version of the article: http://eau.sagepub.com/content/19/1/81

3. BBS- Bangladesh Bureau of Statistics (2001) Bangladesh Population Census 2001, Dhaka, Ministry of Planning, Gov. of Bangl

4. Begum D. A. (2004). Air pollution: A Case Study of Dhaka City, presented at the conference "BAQ-2004", Organized by Society of Indian Automobile Manufacturers, Agra, India, December, 2004.

5. Begum D.A and Ahmed K.M (2010) Air Pollution Aspects of Dhaka City, presented at International conference on Environmental Aspects of Bangladesh (ICEAB10), Japan, Spet.2010.

6. Islam Nazrul and Salma A. Shafi (2008) *Proposal for Comprehensive Housing Development for Dhaka*. Centre for Urban Studies (CUS)

Chapter-VII

Conclusion

Chapter VII
Conclusion

The issue of climate change is still debatable in the international arena. But the changing climatic expression in some parts of the world is reality. On the other hand the problem of air pollution is an established reality in this fossil fuel and industrial based world economy. In urban areas the expression of these problems are diversified according the geo-physical, economic, demographic and social context. But it is now reality that urban areas are going to face the integrated problems arouse from these two problems. Different parts of the world will face the problem in different magnitudes. In this global and local context the urban planning and policy tools can act as an effective way to mitigate and adapt the problems. Consideration of the issues in urban planning and policy will give effective way to the city to come out from this problem.

In the study the effort was to draw out what are the actual planning and policy tools can bring in consider to face this problem. Not only listing the tools, the study tried to go in depth analysis in which way they are working against the problems. The whole study designed based on the two dimensions of the problems of air pollution and climate change. In the interaction level of air pollution and climate change it is identified that there are two influenced dimension of air pollution and climate change. One is the emission dimension and another one is the impact dimension. Based on these two dimensions different planning and policy tools are identified and discussed. Emission control tools are discussed under two broad categories: direct and indirect emission control tools. Some tools are applicable for controlling the emission problems such as densification, Urban form, Urban design aspects, Transit Oriented Development, Floor area Ratio, Zoning, Travel Demand Management, Livelihood improvement strategy. These are the tools listed as indirect emission control tools. Among the direct emission control tools mitigation fee and emission density zoning are listed as they are directly related with the comprehensive urban planning scheme. On the other hand under the impact dimension of the problems the adaptation tools of Urban Heat Island problem at city level are framed out. The tools and techniques are identified in three broad categories: Anthropogenic heat reduction, Improvement of Artificial surface coverage and improvement of urban structures. It is found that different planning and policy tools work on different components of urban area to mitigate and adapt the problem of climate change and air pollution. Different tools are interlinked in somewhere at their operation as well as implementation level. At implementation level the most important thing is the consideration of the tradeoffs among the different tools. All tools are not applicable in an area at the same time. From this consideration a common policy framework developed considering the influence domain of the listed UPP tools.

A broad scale policy framework was developed that can utilize to apply those tools in a guided way in urban area. Three basic component of this policy framework are urban system optimisation, urban growth management and urban development compensation. At the end of this study an implementation field is analysed as a test case of the developed framework and analysed the implementation context in relation with the components of the developed policy framework. It is found that application of different tools in relation to adapt UHI will be fitted best concerning the policy of Building delivery system and urban drainage system of Dhaka city.

This study has a clear potentiality to conduct more vigorous study in future level. In a very general way this study can be extended in the complexity analysis of those planning and policy tools. What type of complexities will have to consider and at which scale can be a future branch of this study. The complexities can be analysed in three broad dimensions: time dimension, human dimension and space dimension. From decision making and implementation point of view how the different tools work considering these three dimensions can be a future level of exploration of this study.

It can't be said that there are no other tools beyond the listed ones in this study instead it can be said that this study will give a path to consider those tools against the problems of climate change and air pollution at city level under broad urban planning and policy framework. Moreover, it is also mentionable that all of the tools are not applicable at a time. In case of application of the tools the most important thing is to analyse the context and frame the way to apply those planning and policy tools in a specific context.

References

References:

Sl No. **A**

01 Ahmed N. (1997), "Air Pollution in Dhaka City," Key note speech at ChE Division of IEB, May, 1997.

02 Alam Mozaharul and Rabbani Golam M.D (2007). Vulnerabilities and Responses to Climate Change for Dhaka, *Environment and Urbannization.* Retrieved from: http://eau.sagepub.com/content/19/1/81

03 Alonso, William (1964) *Location and Land Use*. Cambridge, MA: Harvard University Press

04 Arnfield, A. J. (2003) Two Decades of Urban Climate Research: A Review of Turbulence, Exchanges of Energy and Water, and The Urban Heat Island, *International Journal of Climatology,* 23, pp. 1–26.

B

05 Babcock R Lyndon, Jr., Niren L. Nagda, Edward J. Koval May (1975) Land-use Aspects of Air-Quality Management. *Science of the Total Environmen*t Vol 4, No 1, pp. 63-77

06 Bai Xuemei, Balk Deborah, Braga Tania, Douglas Ian, Elmqvist Thomas, Rees William, Satterthwaite David, Songsore Jacob, Zlotnik Hania (2005) Urban System. In: Hassan Rashid M., Scholes Robert, Ash Neville (2005) *Ecosystems and human well being: current state and trends : findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment* Island Press, Newyork. Retrieved from: http://books.google.com/books?id=UFVmiSAr-okC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

07 Baldasano J, Soriano C, Boada L (1999) Emission Inventory for Greenhouse Gases in the City of Barcelona, 1987-1996, *Atmospheric Environment* Vol 3, pp. 3765-3775.

08 Batuad Alain (2002) Urban Planning and Air Quality. South Asia Urban Air Quality Management Briefing Note NO.6, UNDP/World Bank Energy Sector Management Assistant Programme (ESMAP)

09 3. BBS- Bangladesh Bureau of Statistics (2001) Bangladesh Population Census 2001,
Dhaka, Ministry of Planning, Gov. of Bangl

10 Begum D. A. (2004). Air pollution: A Case Study of Dhaka City, presented at the conference "BAQ-2004", Organized by Society of Indian Automobile Manufacturers, Agra, India, December, 2004.

11 Begum D.A and Ahmed K.M (2010) Air Pollution Aspects of Dhaka City, presented at International Conference on Environmental Aspects of Bangladesh (ICEAB10), Japan, Spet.2010.

12 Bertaud, Alain, and Stephen Malpezzi (2001). Measuring the Costs and Benefits of Urban Land Use Regulation: A Simple Model with an Application to Malaysia. *Journal of Housing Economics* Vol:10, No 3, pp:393–418.

13 Bertuad Alain (2004) Spatial Organization of Cities: Deliberate Outcome or Unforeseen Consequence. Working Paper, Institute of Urban and Regional Development, University of California at Berkeley.

14 Borrego, C., Martins, H., Tchepel, O., Salmim, L., Monteiro, A. and Miranda, A.I. (2006) How Urban Structure can Affect City Sustainability from an Air Quality Perspective. *Environmental Modelling and Software* volume 21, pp.461-467

15 Burtraw and Toman (1997), The Benefits Of Reduced Air Pollutants In The U.S From Greenhouse Gas Mitigation Policies, discussion paper, Resources for the Future.

16 Bytnerowicz Andrzej, Kenji Omasa, Elena Paoletti (2007), Integrated Effects of Air Pollution and Climate Change on Forests: A Northern Hemisphere Perspective, *Environmental Pollution* Vol.14, pp 438-445

C

17 Calgory City Council (2004) *Transit Oriented Development, Best Practices Handbook*, The City of Calgary, Land Use Planning and Policy

18 Calthorpe, Peter (1990) Transit-Oriented Development Design Guidelines for the County of Sacramento, Peter Calthorpe Associates (p. 5).

19 CAPCOA: California Air Pollution Control Officers Association (2008). *California Environmental Quality Act and Climate change.*

20 Cervero R, Duncan M. (2003). Walking, Bicycling and Urban Landscapes: Evidence from The San Francisco Bay Area. *American Journal of Public Health*, Vol 93,No 9, pp.1478–1483.

21 Cervero Robert and Radisch Carolyn (1995) *Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods*. UC Transportation Center, UCTC 281 (www.uctc.net).

22 Cervero, R. and Duncan, M. (2002) Benefits of Proximity to Rail on Housing Markets: Experiences In Santa Clara County, *Journal of Public Transportation*, Vol 5, pp. 1–18.

23 Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research D*, Vol 2, No3, pp 199–219.

24 Cervero, Roberto (2004), *Transit oriented development in United States: Experience challenges, and prospects* United States, federal transit administration, transit cooperative research programme [available at: http://books.google.com/books?id=a6__pNpM44MC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false]

25 Chambers R & Conway G, (1992) *Sustainable Rural Livelihoods: Practical Concepts For The 21st Century*, IDS discussion paper No 296, IDS: Sussex

26 CO2 Emission Calculator, Calculated on October, 2010. Retrieved from: http://www.transportdirect.info/Web2/JourneyPlanning/JourneyEmissionsCompare.aspx

27 Condon M. Patrik, Duncan Cavens and Nicole Miller (2009) Urban Planning Tools for Climate Change Mitigation. *Lincoln Institute of Land Policy*

28 Coutts Andrew M., Berineger Jason and Taper Nigel J. (2006) Impact of Increasing Urban Density on local Climate: Spatial and Temporal Variations in the Surface Energy Balance in Melbourn Australia. *Journal of Meteorology and Climatology*, vol 46, pp. 477-493

D

29 Dajania Jarir S., Tedd H. Jettb and P.Aarne Vesilindc (1977) Air pollution Control through Land-Use Planning. *Urban Systems* Vol 2, No1, pp. 35-43

30 Davis Todd and Hale Minica (2007) *Public Transportation's Contribution to Greenhouse Gas Reduction*, SAIC: From Energy to Solutions

31 Dill Jennifer (2005) *Measuring Network Connectivity for Bicycling and Walking*, School of Urban Studies and Planning, Portland State University.

32 Dodman David (2009) Urban Density and Climate Change. Analytical Review of the Interaction between Urban Growth Trends and Environmental Changes, United Nation Population Fund (UNFPA),

33 DOE: Department of Ecology, State of Washington (2010), *What is Climate Change*, Retrieved from the official website on July,2010 http://www.ecy.wa.gov/climatechange/whatis.htm

34 Dunn, S. (1996), Green Auto Racing. Natural Resources Defense Council, Washington.

E

35 EC: Environment Canada (2010), *Clean Air, Climate Change and Stratospheric Ozone Depletion* Retrieved on September from the website of Environment Canada: http://www.ec.gc.ca/air/default.asp?lang=En&xml=C6DCEC3F-EA13-4DE9-B735-6F62328B8BB1

36 EEA: European Environment Agency (2000). Europe's Environment – The Dobris Assessment. Copenhagen.

37 EPA Environmental protection agency, USA (2010), *Recent Climate change*, retrieved on September from http://www.epa.gov/climatechange/science/recenttc.html

38 EPA, (2001) Our Built and Natural Environments: A Technical review of the Interactions between Land Use, Transportation and Environmental Quality (EPA 231-R-01–002). Washington.

39 EPA,Sweden (2009) *Climate Change and Air Pollution-Two Sides of the same Coin* Editor: Håkan Pleijel, The Swedish EPA financed Book, ISBN 978-91-620-1278-6

40 Ewing, R., & Cervero R. (2001). Travel and the built environment: A synthesis. Transportation Research Record, No 1780, pp. 87–114. Retrieved on October,2010from: http://depts.washington.edu/trac/concurrency/lit_review/trr1780.pdf

41 Ewing,R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D., McCann, B. and Goldberg, D. (2007) *Growing Cooler: The Evidence on Urban Development and Climate Change.* Chicago: Urban Land Institute

F

42 Farguson Erik ,(1998) Travel Demand Management, *Journal of planning literature* Vol 13, pp 100-126 Retrieved on October, 2010 from: http://jpl.sagepub.com/content/13/1/100.citation

43 Frank Lawrence D, Stone Bian Jr, William Bachman (2000) Linking Land Use with Household Vehicle Emissions in the Central Puget Sound: Methodological Framework and Findings *Transportation research Part D5* pp:173-199

44 Frank Lawrence, Sallis JF, Conway T, Chapman J, Saelens B, Bachman W (2006) Multiple Pathways from Land Use to Health: Walkability Associations with Active Transportation, Body Mass Index, and Air Quality. *Journal of the American Planning Association* Vol. 72 No. 1.

45 Frank, J., and P. Downing. (1988). Patterns of Impact Fees Use. In *Development Impact Fee*, edited by A. C. Nelson, 3-21. Washington, DC: Planners.

46 Frank, L.D., Pivo, G., (1995). Impacts of Mixed use and Density on the Utilization of Three Modes of Travel: Single Occupant Vehicle, Transit, and Walking. Transportation Research Record, Washington, DC.

47 Frumkin H, Frank L, Jackson R. (2004). *Urban Sprawl and Public Health: Design, Planning, and Building for Healthy Communities*. Washington, DC: Island Press.

G

48 Glaeser Edward L, Kahn Mtthew (2008) The Greenness of Cities. Harvard Kennedy School / Taubman Center for State and Local Government. Policy Brief, March, 2008. Retrieved from: http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers programs/centers/taubman/policybriefs/greencities_final.pdf

49 Gorsevski Virginia, Taha Haider, Quattrochi Dale, Luvall Jeff,(#) Air pollution Prevention through Urban Heat Island Mitigation an Update on Urban Heat Island Pilot Project.

50 Gottdiener, M., Budd, L. (2005) *Key Concepts in Urban Studies*. London, Sage.

51 Grant Michael, Lissa Ecola and Wendy Messenger (2007) Transportation Demand Management Programs as an Emissions Reduction Strategy: New Challenges and Opportunities, ICF International

H

52 Handy Susan and Mokhtarian Patricia L. (2005) Which Comes First: The Neighborhood Or The Walking?, ACCESS 26, University of California Transportation Center (www.uctc.net), Spring 2005, pp. 16-21. Retrieved on September,2010 form : www.des.ucdavis.edu/faculty/handy/walking_or_neighborhood.pdf

53 Handy Susan, Paterson Robert G. and Butler Kent (2004) *Planning for Street Connectivity: Getting From Here to There*, Planning Advisory Service Report 515, American Planning Association

I

54 IIASA: International Institute for Applied System Analysis (2004), The Regional Air Pollution Information and Simulation (RAINS) Model. Retrieved on July,2010 from: *www.iiasa.ac.at/rains/review/review-approach.pdf*

55 IPCC: Inter Governmental Panel on Climate change (1990) *Potential Impacts on Climate Change*, Report from working group II to IPCC Retrieved on September form: http://www.ciesin.org/docs/001-011/001-011.html

56 IPCC (2007) *The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the IPCC (Cambridge University Press), ISBN 978-0521-88009-1 (2007a)

57 IPCC: Intergovernmental Panel on Climate Change (2001) *Working Group I Third Assessment Report,* Cambridge, UK, Cambridge University Press.

58 Islam Nazrul and Salma A. Shafi (2008) *Proposal for Comprehensive Housing Development for Dhaka*. Centre for Urban Studies (CUS)

J

59 Jabareen, Y. (2006) Sustainable Urban Forms: Their Typologies, Models, and Concepts. *Journal of Planning Education and Research,* Vol 26, pp. 38-52.

60 Jacob Daniel J, Darrell A. Winner b (2009), Effects of Climate change on Air Quality, *Journal of Atmospheric Environment,* No 43 (51-63)

61 Jirak Israel L. and William R. Cotton (2006), Effect of Air Pollution on Precipitation along the Front Range of the Rocky Mountains, *Journal of Applied Meteorology and Climatolog*y 2006; 45: 236-245

K

62 Kent J. H. and Mudford N. R. (1979) Motor Vehicle Emissions and Fuel Consumption Modelling. *Transportation Research,* Vol 13A, pp 395-406.

63 Kropp Juergen & Reckien Dianna (2009), *Cities and climate change which option do we have for a safe and sustainable future*

64 Kulash, W. (1990). Traditional Neighborhood Development: Will the Traffic Work? In: Proceedings of the Eleventh Annual Pedestrian Conference, Bellvue Washington.

65 Kuzmyak Richard J., and Pratt Richard H. (2003), *Land Use and Site Design: Traveler Response to Transport System Changes*, Chapter 15, Transit Cooperative Research Program Report 95, Transportation Research Board (www.trb.org); Retrieved form: http://gulliver.trb.org/publications/tcrp/tcrp_rpt_95c15.pdf.

L

66 Lee D O. (1993) Climate change and air quality in London. *Geography* No.78, pp77 -79

67 LFC: Lawrence Frank & Company Inc, Mark Bradley and Keith Lawton Associates. (2005a). *Travel Behavior, Emissions, & Land Use Correlation Analysis in the Central Puget Sound*. Prepared for the Washington State Department of Transportation, Olympia WA. Report no. WA-RD 625.1.

68 LFC:Lawrence Frank & Company (2008) *Reducing Global Warming and Air Pollution: The Role of Green Development in California,* prepared for Environmental Defence Fund.

69 Litman Todd (2010) *Land Use Impacts on Trans port: How Land use Factors Affect Travel Behaviour*. Victoria transport policy Institute with Rowan Steele.

70 Los Angles Housing Department (2010), What are the Basics of Land Use and Planning Regulations, Retrieved on October, 2010 from : http://www.ci.la.ca.us/LAHD/curriculum/gettingfacts/planning/planconcepts.html

71 Lyons T.J, Kenworthy R.J and Newman P.W.G (1990) Urban Structure and Air Pollution. *Atmospheric Environment volume* ,Vol 24B, No 1, pp 43-48

M

72 Marshall Julian D, Brauer Michael, and D. Frank Lawrence (2009), Healthy Neighborhoods: Walkability and Air Pollution, *Environ Health Percep,*Vol 117, pp 1752–1759 (2009). Retrieved from: via http://dx.doi.org/

73 McPherson, G.E. (1994). *Cooling Urban Heat Islands With Sustainable Landscapes. In: Platt, R., Rowntree, R., Muick, P.,* The Ecological City. University of Massachusetts Press, Amherst, MA.

74 Meikle Sheilah, Ramasut Tamsin, Wlaker Julian (2001): *Sustainable Urban Livelihoods:Concepts and Implications for Policy,* Working Paper No:112.

75 Moudon Anne Vernez (1996) *Effects of Site Design on Pedestrian Travel in Mixed Use, Medium-Density Environments*, Washington State Transportation Center, Document WA-RD 432.1, Retrieved from: www.wsdot.wa.gov/ppsc/research/onepages/WA-RD4321.htm.

76 Moudon AV, Lee C, Cheadle AD, Garvin C, Johnson D, Schmid TL, Weathers RD, and Lin L (2006). Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights. *Journal of Physical Activity and Health* Vol 3, Suppl 1, pp. S99-S117

77 Muth, Richard F. (1969) *Cities and Housing*. Chicago: University of Chicago Press.

N

78 NEIAPETD: National Emissions Inventory Air Pollutant Emissions Trends Data, (2002) Retrieved from: http://www.epa.gov/ttn/chief/trends/index.html#tables.

79 Nelson Dick, Niles John, Aharon Hibshoosh (2001), *A New Planning Template For Transit Oriented Development,* Mineta Transport Institute College of Business, San Josè state University.

80 Neuman M (2005) The Compact City Fallacy. *Journal of Planning Education and Research,* Vol 25, pp. 11-26

81 Newman P. & Kenworthy, J. R. (1999), *Sustainability and Cities: overcoming automobile dependence*, Island Press, Washington DC

82 Newman, Peter W. G. and Kenworthy, Jeffrey R. (1989) Gasoline Consumption and Cities. *Journal of the American Planning Association*, Vol 55, No1, pp.24 - 37

83 Nicholas James C, Julian Juergensmeyer Conrad (2003), Market Based Approach to Environmental Preservation: To Environmental Mitigation Fees and Beyond, *Natural resource Journal,Vol:43 pp:837-864*

84 NOAA:National Oceanic and Atmospheric administration (2008), *State of the Climate Global Analysis Annual*. Retrieved on September,2010 from: http://www.ncdc.noaa.gov/sotc/index.php?report=global&year=2008&month=ann

85 Nolon John R. (2007) Zoning Transportation and Climate Change. *New York zoning and law practice report*. Vol.8, No. 2

86 Norman F.Kron Jr, Alan S. Cohen and Linda M. Mele (1978) *Emission Density Zoning Guidebook: A Technical Guide to Maintaining Air Quality Standards through Land-Use-Based Emission Limits,* Environmental Peotection Agency, US.

87 NRC:National Research Council, Committee on Tropospheric Ozone Formation and Measurement, (1991) *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Academy Press, Washington, DC.

O

88 Oke T.R.(1987). *Boundary Layer Climates,* Second Edition., London: Methuen and Co., 435.

89 Oke, T.R. (1997) Urban climates and global change. In Perry A and Thompson R eds *Applied Climatology: Principles and Practices*, pp. 273–287. London: Routledge.

P

90 PBQD (1994), *Building Orientation;* Supplement to The Pedestrian Environment, 1000 Friends of Oregon (www.friends.org).

91 Portland (1995) *Parking Ratio Rule Checklist; Self-Enforcing Strategies*, City of Portland.

R

92 Raes Frank (2006) Climate Change and Air Pollution- Research and Policy, Global Change News Letter No.65 March 2006.

93 Ramanathan V, Feng Y. (2009) Air pollution, Greenhouse Gases and Climate Change: Global and regional perspectives, *Journal of Atmospheric Environment*, No 43, pp 37-50

94 Ronald G. Prinn, John Reilly, Marcus Sarofim, Chien Wang and Benjamin Felzer (2005), Effects of Air Pollution Control on Climate, MIT Joint programme on Science and Policy of Global Change. Report No:118

95 Rosenzweig, C.E., Solecki, W.D. (Eds.) (2001) Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region, Columbia Earth Institute, New York.

S

96 Sallis Dr. James, Saelens Dr. Brian, McCann Consulting, GeoStats LLC, and Washbrook Kevin (2005). *A Study of Land Use, Transportation, Air Quality and Health in King County, WA*. Prepared for the King County Office of Regional Transportation Planning, Lawrence Frank and Company (LFC) Inc.

97 Satterthwaite D (1999) The Key Issues and the Works Included' in Satterthwaite D (ed) *The Earthscan Reader in Sustainable Cities*, pp 3-21. London, Earthscan.

98 Schwele, D. (1995), Public Health Implications of Urban Air Pollution in Developing Countries. Proceedings of the 10th World Clean Air Congress, Espoo Finland, 28 May - 2 June.

99 Simanaitis D. J. (1977) Emission Test Cycles around the World. *Automotive Engng*. Vol 85, No 8, pp 34-43.

100 Sridhar kala Seetharam (2010) Impact of Land use Regulations:Evidence from India's cities. *Journal of urban studies,* vol 47,No7

101 Srivastava (2009), *Environmental Pollution* APH Publishing,ISBN: 8131304787, 9788131304785 Retrieved from: *http://books.google.com/books?id=3Tn087o8JoUC&pg=PA5&dq=definition+of+air+pollution&hl=en&ei=yijwTPe9AYbrOf-bvboK&sa=X&oi=book_result&ct=result&resnum=1&ved=0CCoQ6AEwAA#v=onepage&q=definition%20of%20air%20pollution&f=false*

102 Statewide Transit Oriented Development Study (2002), *Factors for Success in California,Final Report* September, 2002

103 Stedman J R, (2004) The Predicted Number of Air Pollution Related Deaths In The UK During The August 2003 Heat wave. *Atmospheric Environment,* vol l38, pp 1083-1085

104 Steemers Koen (2002) Energy and the City: Density, Buildings and Transport. *Journal of Energy and building,* Vol 35, No 1,pp.3-14

105 Suybros Nhean, Dalina Moeng, Kemly Ouch and Chumnith Sam, (Unknown) THE IMPACT OF BIOMASS FUEL CONSUMPTION ON AIR QUALITY AND HUMAN HEALTH: A case study at Prey Chisak and Prey Pring Tboung village, Choam Chau Commune, Dangkao District, Phnom Penh, Cambodia, Department of Environmental Science, Royal University of Phnom Penh

106 Swart R, Amann M,Raers F and Tuinstra W (2004), A Good Climate For Clean Air: Linkage Between Climate Change And Air Pollutants, *Climatic change*, No 66, pp263-269

T

107 Taha, H., D. Sailor, and H. Akbari. (1992). *High-Albedo Materials for Reducing Building Cooling Energy Use.* Lawrence Berkeley National Laboratory Report No. 31721 UC-350: 71

108 TCRP:Transit Cooperative Research Programme (2004) *Transit-oriented development in the United States: experiences, challenges, and prospects*. Report No. 102, TCRP, Washington, DC. Retrieved on October,2010 from: *trb.org/publications/tcrp/tcrp_rpt_**102**.pdf*

U

109 UNDP (A), (1997) *Productive Employment And Poverty Eradication. How Can Livelihoods be More Sustainable*, UNDP

110 UNECE:United Nations Economic Cooperation for Europe (2010), *Air Pollution and climate change tackling both problems in tandem* Retrieved on September,2010 from : http://www.unece.org/press/pr2003/03env_p02e.htm

111 UNEP: United Nations Environment Program (1999), *Global Environment Outlook*, Earthscan publications Ltd., London. pp 398.

112 UNFPA: United Nations Population Fund (1999). The State of World Population 1999. New York: UNFPA.

113 USEPA (1984) User's guide to MOBILE3 (Mobile Source Emissions Model), EPA 460/3-84-002. U.S.E.P.A., Ann Arbor, Michigan.

114 USEPA (2004), *Improving Air Quality Through Land Use Activities - EPA Guidance*, EPA420-R-01-001, Office of Transportation and Air Quality, USEPA (www.epa.gov); Retrieved on October, 2010 from: www.epa.gov/OMS/stateresources/policy/transp/landuse/r01001.pdf.

V

115 Vooget James A (2004), *Urban Heat Island:Hotter cities*, Retrieved on November ,2010 from http://www.actionbioscience.org/environment/voogt.html

116 VTPI: Victoria Transport Policy Institute (2005) *Land Use Impacts on Transport*, Online TDM Encyclopedia. Retrieved on September, 2010 from http://www.vtpi.org/tdm/tdm20.htm

W

117 Wendell Cox (2000) *How Urban Density Intensifies Traffic Congestion and Air Pollution.* Arizona Issue Analysis, Wendell Cox Consultancy.

118 Wikipedia (2010) *Linkage and Mitigation Fee*, Retrieved on October, 2010 from: http://en.wikipedia.org/wiki/Mitigation_fee

119 Wilby Robert L, (2007) Constructing Climate Change Scenarios Of Urban Heat Island Intensity And Air Quality. *Environmental and Planning B: planning and design*, vol 35, pp902-919.

120 World Bank (1996) *The role of World Bank in Transport Sector*.

121 World Bank (2002) *South Asia Urban n Air Quality Management Briefing Note No 6.*

122 World Meteorological Organization. (1984). Urban Climatology and its Applications with Special Regard to Tropical Areas. *Proceedings of the Technical Conference Organized by the World Meteorological Organization*, Mexico, 26-30 November 1984 (WMO-No. 652): 534.

Y

123 Yamamoto Yoshika, (2006) Measure To Mitigate Urban Heat Island. *Science and Technology Trend,* Quarterly Review no: 18