5th SASTech Iran | Mashhad May 12 - 17 | 2011
5th Symposium on Advances in Science & Technology

Urban Spatial Structure design of coastal cities in order to reduce undesirable effects of climate changes (the case study: Fereidunkenar)

Mohammadreza Haghjoo, Member of Scientific board, Faculty of Art and Architecture Mazandaran University, Babolsar, Iran.urplanner_mh@yahoo.com

Maede Hedayatifard, Master Student of Urban and Regional Planning, Faculty of Urbanism and Architecture, Shahid Beheshti University, Tehran, Iran, md.hedayati@gmail.com

Presenter name: Mohammadreza haghjoo

Abstract

Climate change is one of the most important environmental challenges in the world. Nowadays urban unsustainable activities have enhanced the Earth's 'natural greenhouse effect' and have led to some critical situations in environment, specially the increase in the earth temperature. It is predicted that, with global warming, global average sea levels may rise by between 7 and 36 cm by the 2050s (Roaf, et.al, 2005). As amount of the world's population are living in the coastal areas, it is essential to plan for coastal cities in order to reduce the undesirable effects of climate changes. The northern coastal corridor of Iran, which has allocated 20% of whole population, has a key role in the reduction of climate changes effects. Urban spatial structure as the base of spatial development determines the energy use and CO2 emission of a city, since it determines the physical space form of the city and deeply affects the modes of socio-economic activities. Sustainable design of Urban Spatial structure with the orientation of climate adaptation is effective in the reduction of greenhouse gasses emission. Fereidunkenr is a coastal city beside Caspian Sea. The result of this article shows that principles of sustainable spatial structure in Fereidunkenr are unsustainable and it would lead to the increase in CO2 emission and finally would have undesirable effects in the coastal region of Iran. This article aims to design the sustainable spatial pattern for Fereidunkenr that is compatible with climate and would reduce unsuitable effects of climate changes.

Key words: urban spatial structure, climate change, coastal corridors, urban sustainability indicators

1- Introduction

The current scientific and political consensus, as represented by the IPCC, is that rising man made emissions of carbon dioxide and other GHGs are causing a significant rise in global average temperatures, over and above that which might be due to any natural phenomena (IPCC, 2007). Regional and local climate change is more rapid than global climate change and directly affects the activities of local people. To be specific, urban climate change is a kind of local climate change caused by rapid urbanization (Huang, Wang, Shi, 2009). It is predicted that, with global warming, global average sea levels may

rise by between 7 and 36 cm by the 2050s (Roaf, et.al, 2005). As amount of the world's population are living in the coastal areas, it is essential to plan for coastal cities in order to reduce the undesirable effects of climate changes. The northern coastal corridor of Iran, which has allocated 20% of whole population, has a key role in the reduction of climate changes effects. The term urban structure refers to the pattern or arrangement of development blocks, streets, buildings, open space and landscape which make up urban areas. It is the interrelationship between all these elements, rather than their particular characteristics that bond together to make a place (English housing corporations, 2000). So urban spatial structure as the base of spatial development determines the energy use and CO2 emission of a city, since it determines the physical space form of the city and deeply affects the modes of socio-economic activities. Sustainable design of Urban Spatial structure with the orientation of climate adaptation is effective in the reduction of greenhouse gasses emission. In this article, the existent spatial structure of Fereidunkenar is surveyed with consideration of some sustainability indicators that spatial structure is responsible to ensure them. The aim of this article is to design the sustainable spatial pattern via urban spatial structure, which can create a sustainable coastal city and would decrease the threats of climate change effect on coastal corridors.

2- The vulnerability of coastal urban corridors encountering climate changes

Emissions of greenhouse gases (GHGs) have damagingly increased over the last two centuries as a result of certain economic activities and demographic growth. The increased concentration of GHGs as a result of human activities has enhanced the Earth's 'natural greenhouse effect' and has led to climatic variability and change. The Intergovernmental Panel on Climate Change (IPCC) noted the United Nations Framework Convention on Climate Change (UNFCCC) definition of climate change as a change in climate that is attributable directly or indirectly to human activity which alters atmospheric conditions (IPCC, 2001). Climate change is expected to result in increased seasonal and inter- annual variability, as well as generating slow changes in mean conditions such as sea level, air temperature and precipitation rates; an increase in the frequency of extreme events; and possibly abrupt systems changes (Tompkins, 2005). If the density of CO2 becomes as twice as 2100, the average temperature of Iran would get 1.5 to 4.5 centigrade increase, that would lead to the important changes in water resources, energy demand, agricultural efficiency and the changes in coastal corridors. This is predicted to lead to reduced food yields, significant water shortages, sea level rise on a scale that will threaten coastal cities (Marsden and Rye, 2009). Fereidunkenr is a coastal city beside Caspian Sea. Because of its potential for attracting population as tourism industry, and the agricultural function of the city as the first producer of rice in Iran, it has high vulnerability encountering climate change effects.

3- Urban factors in GHG emission increase

Cities are the main producers of green house gasses. The urban sprawl, unsustainable urban forms and transportation, demolition of green lands, and the increase in the use of flues, increased the rate of GHG emission in the cities. The special report of countries to IPCC in 2000, shows that the activities which are producing GHG emission differs in developed and under developed countries. Transportation and residential sector in under developed countries are responsible for 16% and 7% of green house gas (GHG) emissions, while these sectors in developed countries have 25% and 9%. This is illustrated in figure1. Transportation is the most producer of GHG in the cities in both developed and under developed countries. So the emphasize is on road transport as it contributes 93% of all domestic emissions from transport (DfT, 2007). Urban spatial structure, determines the

pattern of traffic organization in the city. The well designed pattern can considerably effects the GHG emissions.

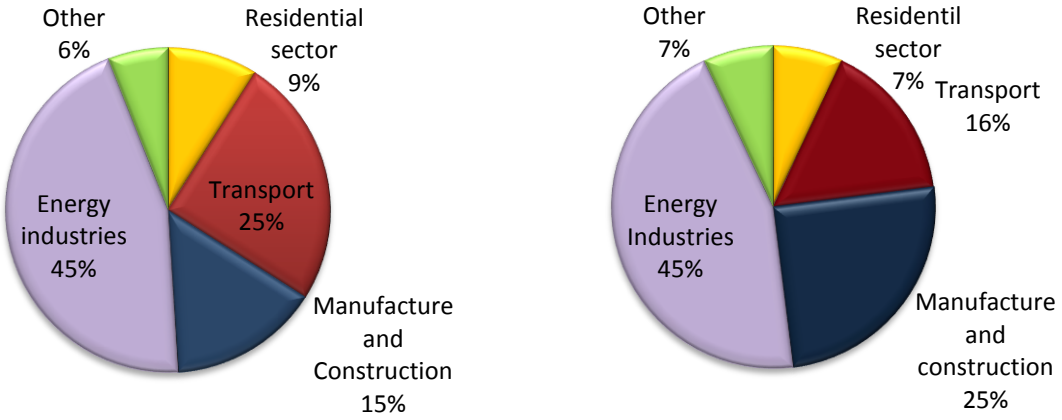


Figure 1: Factors of GHG emission in developed and under developed countries (UNFCCC2000)

4- The effects of urban coastal corridor's spatial structure on climate changes

Climate change is the result of a significant rise in global average temperature. Depending on the scale of the rise in average temperatures (Dasgupta, et al., 2007). This is predicted to lead to reduced food yields, significant water shortages, sea level rise on a scale that will threaten many major cities, species extinction, extreme weather, and ultimately, abrupt and large scale changes in global climate. Together, these changes are likely to bring about enormous social and economic upheaval. Their impacts on the economy (in terms of reduced production, and the costs of adaptation/mitigation) are also likely to be large: 5% of world GDP per year if no action is taken, rising to 20% if and when catastrophic climate change occurs (Stern et al., 2006). The term urban structure refers to the pattern or arrangement of development blocks, streets, buildings, open space and landscape which make up urban areas. It is the interrelationship between all these elements, rather than their particular characteristics that bond together to make a place. The urban structure provides the foundations for detailed design of the constituent elements. It creates a coherent framework, which forms the basis of the design of individual developments - quite possibly by different actors - in order to achieve integration, functional efficiency and environmental harmony.(English housing corporations, 2000) Although the adjustment of industrial structure, healthy life style and technological innovation are helpful to cut down the CO2 emission and energy use in production and living, however, these measures can hardly change traffic volume and relative energy consumption and emission determined by urban spatial structure. Urban spatial planning determines the spatial structure and finally determines the energy use and CO2 emission of a city (LuJia, 2009). The density of land uses in the coastal urban corridors has an important role in sustainable development of these areas. The main traffic corridors are the main elements of linear urban spatial structures. Short connections and reduction of long corridors in the cities can be effective to decline the urban CO2.This can be possible by increasing the access of different parts of the city to the public services. On the other hand in coastal cities, the main streets are the keys to clean the air by the suitable direction that causes the flow of coastal winds. In the summer mild breezes ventilate buildings and improve comfort whereas in the winter winds increase heat loss. Harness the potential of the wind for natural ventilation and as a possible energy source. Design and

position buildings to minimize funneling and the creation of uncomfortable microclimates (English housing corporations, 2000). So the urban spatial structure that have the collaborative conjunction between its elements including streets, main centers of human activities and the land uses, not only effects the reduction of urban co2 emissions, but also is important to create a sustainable coastal city in the regional scale.

4-1- The conceptual framework for climate change and spatial structure

The sustainable spatial development of a city is in relation with spatial structure and also the climate changes. These relations include the issues such as energy, inner city travels, urban sustainability indicators and the use of natural resources. The conceptual framework of sustainable spatial development of coastal urban corridors can shows the relations of different issues well.

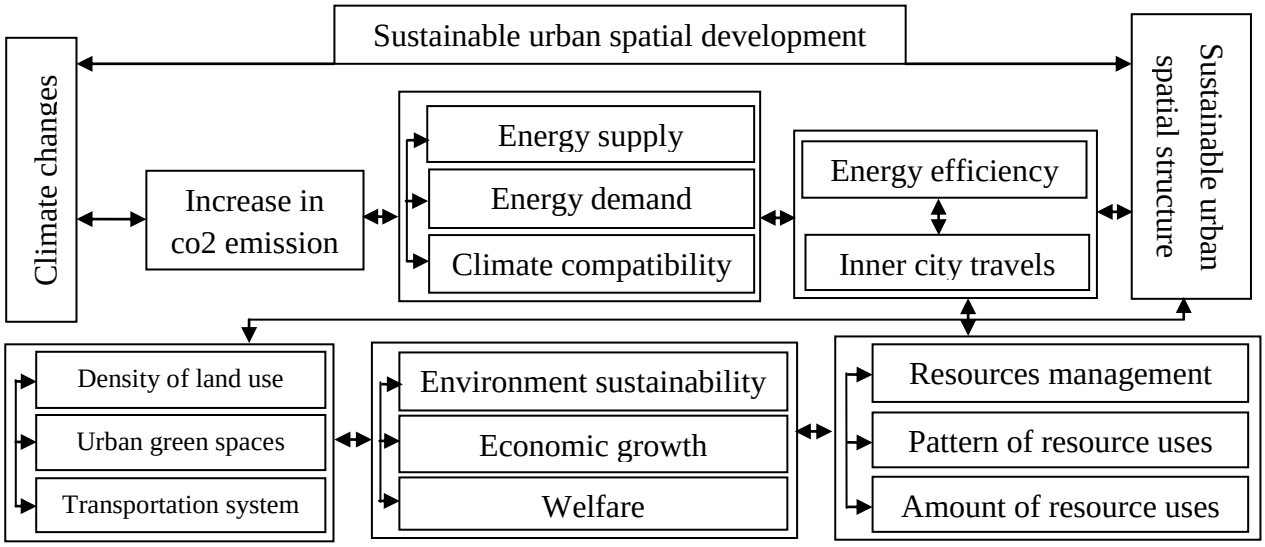
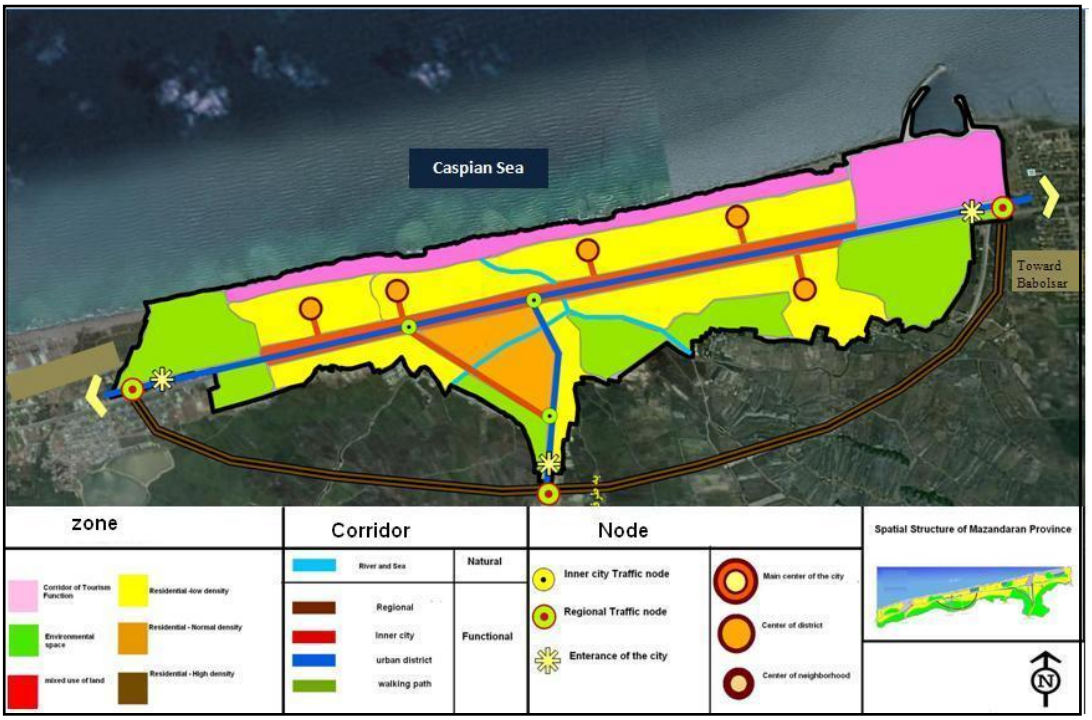


Diagram1: The conceptual framework for effects of spatial structure on climate change- **source**: Authors

5- Urban Spatial Structure in Fereidunkenar

In 2010 the population of Fereidunkenar was estimated in 34452, covering an area of 830 hectare, and a density of 41 inhabitants per hectare. The residential and green space per capita is about 72 m2 and 1.48 m2. Structure of the city is the result of different socio-economical forces that shape the physical spaces. These are productive, consumer and transmitter spaces. In Fereidunkenar, the productive space which involves the commercial activities is along the main street. As the spatial structure is in linear form, along the Caspian Cost, this street plays the key role in the distribution of other elements like urban activity centers. The consumer space, involves the residential and public services spaces that feed the production space and prepare the labor forces. In Fereidunkenar, this space is behind the productive spaces. The transmitter space relates the productive and consumer space by the streets and functional corridors. It produces the most urban GHG emission because of its traffic and car density. To analyze the existent spatial structure of Fereidunkenar, the indicators for sustainable urban structure, that effect the urban carbon budget and climate changes, are prepared. The major criteria for urban sustainability are environmental sustainability, viability and comparability. The indictors of sustainability that are useful for declining climate change effects and relate to urban spatial structure are mentioned in each field. These indicators are the problematic ones toward reduction of climate change effects.



Figur2 : The existent Spatial Structure of Fereidunkenar, 2010

Fields of Sustainability Indicators	**Problematic indicators in Spatial Structure of Fereidunkenar**
environmental	Land use compatibility in neighborhoods
	Suitable Building orientation toward climate
	12m Green space per capita
	Not Building in less than -24 sea level
	natural ventilation
viability	Accessibility to public services in neighborhoods
	Accessibility to city centers
	The suitable distribution of urban public services
comparability	The hierarchy of streets
	The hierarchy of urban centers
	The dynamic side walks
	the dynamic bicycle path

Table 1: The problematic sustainability indicators in spatial structure of Fereidunkenar-
Source: Authors

6- How to design Sustainable Urban spatial structure in coastal Corridors to face climate changes effects

The systematic design of spatial structure is the basic step for spatial sustainability. City is a complex system that has a lot of inner relations. Creating rational relation between social, economical and physical activities would lead to spatial sustainability. All these human activities are in the form of the strategic elements, including urban zones, corridors and nodes in urban spatial organization. It is important to consider these main elements to create sustainable composition of urban zones(like residential, commercial and green spaces), urban corridors (like transportation systems) and urban nodes(like city and neighborhood centers). The nodes of urban activities must have disciplinary hierarchy. The transportation system should relate these nodes well to reduce the inner city travels.

One of the most important critiques on existent spatial structure of Fereidunkenar is that, it doesn't have a dynamic center to include main activities. This is the problem of the cities in linear form. It causes decrease in the accessibility of citizens to public services. Some important elements like transportation system, urban green spaces, settlement density are considered.

Transportation system

The pattern of traffic organization is highly related to the development level of low carbon city since it determines the energy consumption and the tail gas emission of vehicle (LuJia, 2009). The negative impacts of carbon dioxide emissions from the transportation sector on air quality have been well documented over the past two decades, with particular attention being paid to its contribution to global warming and the resulting climate change phenomenon (United Nations, 1987).

Economic	Social	Environmental
Traffic congestion	Inequity of impacts	Air pollution
Mobility barriers	Mobility disadvantaged	Climate change
Crash damages	Community cohesion	Habit loss
Transportation facility costs	Community Livability	Hydrologic impacts
Consumer transportation costs	Aesthetics	Noise Pollution
Depletion of non-renewable resources		

Table2: Negative Impacts of Inefficient transportation systems on sustainability objectives. (Litmann, 2002)

The main street in Fereidunkenar, loads the most important flows of products, human and information in the city. In order to reduce this concentration, the parallel street is designed on the north of the city, along the coastal corridor and by the short linear connections, the equal distribution of traffic would happen. The pattern of traffic organization in Fereidunkenar tends to alter the existent linear structure to grid multicenter structure which prepares urban life for all parts of the city. Creating sidewalks from coast to city center encourage citizens to walk instead of using automobile, so it would decrease the co2 emission from vehicles. In Fereidunkenar the dominate wind is from North and Northwest. These North-South connections including sidewalks and short streets, would lead to the flowing of the wind, creation of the natural ventilation in the city and reduction in concentrated humidity and air pollution.

- ***Urban green spaces***

Besides reducing CO2 emission via technological innovation in green buildings and energy sectors, capture and storage of CO2 by natural eco-system is also of great importance for mitigation global climate changes (Dingxi, Chuanting, Guanxian, 2009). Green land is the natural absorber of CO2. A well planned green system can greatly decrease the CO2 emission and reduce heat island effect of the city (Leung, 2009).

In Fereidunkenar spatial structure, the green spaces are designed inside the residential zone with high density, which prepare viability and environmental sustainability for this zone. On the other hand, the air pollutant land uses inner the city, like unnecessary urban industries are moved to the south border; which involves the mixed-land uses and is surrounded by the green spaces. This green design plays the filtration role and prevents pollution emission. The variety and density of land uses along the coastal corridor are determined with the consideration of environmental capacity of land. As this zone has tourism potential and most of the time attract the population, this especial zone with recreational function, involves green spaces in the buffer of coast and river. Conservation

of agricultural lands around the city makes the green belt and is a breath lung for Fereidunkenar.

- ***Density***

Settlements must be seen as systems working after certain principles. There are clear interactions between road network and settlement structures. The prioritization for motorized traffic with its high speeds resulted in a disintegration of traditional "human-scale" urban functions. A car-orientated design of the road network leads to the phenomenon of urban sprawl (Macoun, 2008). Smart growth is an approach to community design that includes both land-use and transportation elements, and contributes to climate change mitigation by improving energy use and efficiency. It emphasizes strong neighborhood and town centers, mixed-land uses, compact design, with traditional town or city density, a highly connected street network, and transportation alternatives oriented to walking, bicycling, and transit (Frumkin, McMichael, 2008). As Fereidunkenar occupied in the prolific land in the North of Iran, land has an environmental worth. Compact development is important to prevent urban sprawl and unnecessary energy use. So the high density buildings in Fereidunkenar are designed in the south areas and as mentioned above, are surrounded by green spaces. This composition of buildings would make easier the wind flow between buildings and natural ventilation and On the other hand, would prevent the centralization of land uses and population in the coastal corridor lands.

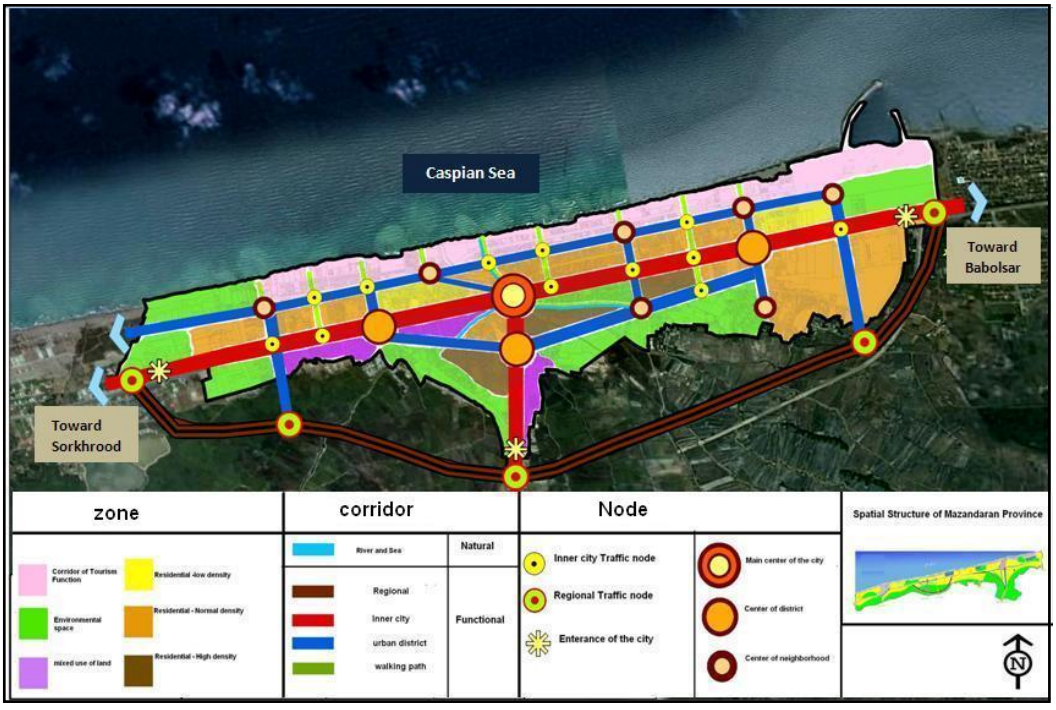


Figure 3: The sustainable design of urban spatial structure for Fereidunkenar

7- **Conclusion** :

Nowadays urban unsustainable activities have enhanced the Earth's 'natural greenhouse effect' and have led to some critical situations in environment, specially the increase in the sea level. As Fereidunkenar is the coastal city in north of Iran, beside the Caspian Sea, it is necessary to design sustainable urban spatial structure, that determines the energy use and gas co2 emission of the city. The sustainability indicators for spatial development that relate the climate change has been considered in existent structure of Fereidunkenar. The unsustainable manner of spatial structure in Fereidunkenar, including

transportation system, distribution of urban activities, the building density in coastal lands and etc, would lead to the increase in city carbon budget. So some alterations are applied in the existent structure and the sustainable form of spatial development for Fereidunkenar is designed that is compatible with climate and would reduce unsuitable its effects.

8- **References**:

1- Dasgupta, S., B. Laplante, S Murray, and D. Wheeler (2009) Sea-Level Rise and Storm Surges. Policy Research Working Paper 4901, Washington: The World Bank-Development Research Group- Environment and Energy Team.

2- DFT, (2007), *Towards a Sustainable Transport System, Supporting Economic Growth in a Low Carbon World*, October 2007, Cm 7226, Department for Transport.

3- Dingxi HUANG, Chuanting LU , Guanxian WANG , (2009), *Integrated management of urban green space – the case in Guangzhou China*, 45th ISOCARP Congress

4- Howard Frumkin, , Anthony J. McMichael, (2008), *Climate Change and Public Health :Thinking, Communicating, Acting*

5- IPCC (2007), *Special Report_ Emission Scenarios, Summery for policy makers*", published for Intergovernmental Panel on Climate Change

6- "IPCC (2001),*Special Report_ Emission Scenarios, Summery for policy makers*", published for Intergovernmental Panel on Climate Change

7- Jinlou Huang, Rusong Wang &Yao Shi, (2009), *urban climate change: A comprehensive ecological analysis of the thermo effects of major Chinese cities.* Ecol. complex: Rutledge

8- Kira Lise Leung,(2009), *Reducing CO2 emissions through the development of a sustainable urban transportation system: the Trinidad case study*

9- Litman, T. (2002). "*Transportation Cost and Benefit Analysis: Applications in Developed and Developing Countries*", in K. Puttaswamaiah (Ed.), Cost-Benefit Analysis: Environmental and Ecological Perspectives (pp. 115-138). Transaction Publishers.

10- LuJia, (2009), *Sptial Planning in Shenzhen to Built a Low Carbon City*, 45th ISOCARP Congress

11- Marsden, G & Rye, T. (2009), *The governance of transport and climate change*, Transport Geography, Elsevier

12- National Oceanic and Atmospheric Administration,(2009),*Our Changing Climate*, U.S. Department of Commerce, USA

13- Roaf, S, Crichton D.& Nicol F. (2005) *Adapting Buildings and Cities for Climate Change, 21st century survival guide*. London: Elsevier

14- Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., Crane, D.,Cruickshank, S., Dietz, S., Edmonson, N., Garbett, S.-L., Hamid, L., Hoffman, G., Ingram, D., Jones, B., Patmore, N., Radcliffe, H., Sathiyarajah, R., Stock, M., Taylor, C., Vernon, T., Wanjie, H., Zenghelis, D., (2006). Stern Review: *The Economics of Climate Change*. HM Treasury, London

15- Thomas Macoun.,(2008), *Principles of a sustainable urban structure*

16- Tompkins, E.(2005).'Planning *for climate change in small islands: Insights from national hurricane preparedness in the Cayman Islands*' Global Environmental Change. Vol. 15

17- United Nations (1987). *Report of the World Commission on Environment and Development: Our Common Future.*: http://www.undocuments.net/wced-ocf.htm

18- *www.unfccc.int*

19- English partnerships the housing corporations, (2000), *urban design compendium Creating the urban structure*, London.